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The Paradox of Global Thrift

Luca Fornaro[t]
Federica Romei[‡]

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Abstract

This paper describes a paradox of global thrift. Consider a world in which interest rates are low and monetary policy cannot stabilize the economy because it is frequently constrained by the zero lower bound. Now imagine that governments complement monetary policy with prudential financial and fiscal policies, because they perceive that limiting private and public borrowing during booms will help stabilize the economy by reducing the risk of financial crises and by creating space for fiscal interventions during busts. We show that these policies, while effective from the perspective of individual countries, might backfire if applied on a global scale. In a financially integrated world, in fact, prudential policies generate a rise in the global supply of savings, or equivalently a drop in global aggregate demand. In turn, weaker global aggregate demand depresses output in countries whose monetary policy is constrained by the zero lower bound. Due to this effect, the world might paradoxically experience a fall in output and welfare following the implementation of well-intended prudential policies.

[t] CREI, Universitat Pompeu Fabra, Barcelona GSE and CEPR; LFornaro@crei.cat.
[‡] Stockholm School of Economics and CEPR; federica.romei@hhs.se

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1 Introduction

The current state of the global economy is characterized by exceptionally low nominal interest rates. In recent years, indeed, policy rates have hit the zero lower bound in most advanced countries (Figure 1, left panel). Against this background a consensus is emerging suggesting that monetary policy, which is expected to be frequently constrained by the zero lower bound in the foreseeable future, should be complemented with prudential financial and fiscal policies. Limiting private and public debt accumulation during booms, the argument goes, will help stabilize the economy, respectively by reducing the risk of financial crises and by creating space for fiscal interventions during busts. According to this view, governments should employ prudential financial and fiscal policies as macroeconomic stabilization tools when the zero lower bound constrains monetary policy.[1]

But what happens if prudential policies are implemented on a global scale? In this paper we show that, as a result, the world can fall prey of a *paradox of global thrift*. In a financially integrated world, in fact, the implementation of prudential financial and fiscal policies increases the global supply of savings. If the demand for savings does not perfectly adjust, the result is a drop in global aggregate demand. In turn, weaker global aggregate demand depresses output in countries whose monetary policy is constrained by the zero lower bound. Due to this effect prudential policies might completely backfire and, paradoxically, lead to a fall in global output and welfare.

To formalize this insight we develop a tractable framework of an imperfectly financially integrated world, in which equilibrium interest rates are low and monetary policy is occasionally constrained by the zero lower bound. We study a world composed of a continuum of small open economies. Countries are hit by uninsurable idiosyncratic shocks. Because of this feature, there is heterogeneity in the demand and supply of savings across countries, and foreign borrowing and lending emerge naturally.

Due to the presence of nominal rigidities monetary policy plays an active role in stabilizing the economy. For instance, when a country experiences a fall in aggregate demand the central bank has to lower the policy rate to keep the economy at full employment. The zero lower bound, however, might prevent monetary policy from fully offsetting the impact of negative demand shocks on output. When this happens the country enters a recessionary liquidity trap. Importantly, if global rates are sufficiently low the world itself can be stuck in a *global liquidity trap*. This is a situation in which a significant fraction of the world economy experiences a liquidity trap with unemployment.

Our global liquidity trap has two key features. First, because of the presence of idiosyncratic shocks, during a global liquidity trap not all countries need to be constrained by the zero lower bound and experience a recession. Moreover, even among those countries stuck in a liquidity trap there is asymmetry in terms of the severity of the recession. The model thus captures situations

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[1] These arguments have been formalized in two seminal papers by Farhi and Werning (2016) and Korinek and Simsek (2016). In this literature, which we describe in detail later on, the need for government intervention arises due to an aggregate demand externality, caused by the fact that atomistic agents do not internalize the impact of their financial decisions on aggregate spending and income.
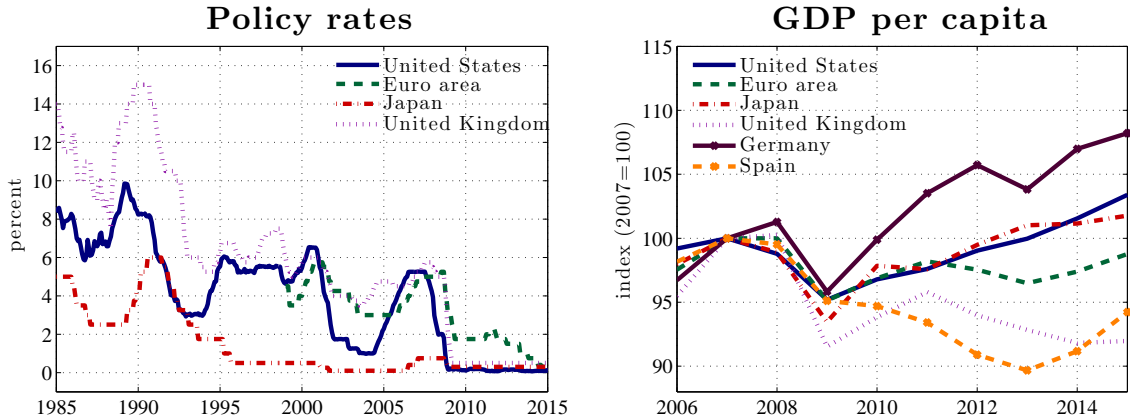
| Policy rates | GDP per capita |

Figure 1: Policy rates and real gross domestic product per capita. Note: the left panel shows the exceptionally low interest rates characterizing the post-2008 period. The right panel highlights the relatively fast recoveries from the 2009 recession experienced by the US and Japan, and the slow recovery in the Euro area and in the United Kingdom. The figure also shows the heterogeneity between fast-recovering core Euro area countries, captured by Germany, and the stagnation experienced by peripheral Euro area countries, captured by Spain. See Appendix H for data sources.

such as the asymmetric recovery that has characterized advanced countries in the aftermath of the 2008 financial crisis (Figure 1, right panel). Second, a global liquidity trap is a persistent event, which is expected to last for a long time.[2] Hence, during a global liquidity trap countries experiencing a boom in the present anticipate that they might fall into a recessionary liquidity trap in the future.[3]

Throughout the paper we contrast two different policy regimes. The first policy regime is a laissez-faire benchmark. In the second regime benevolent, but domestically-oriented, governments actively intervene to influence private agents' financial decisions by means of financial or fiscal policies. While these policies can take a variety of forms, their common trait is that they affect the country's current account. Hence, we refer to them as *current account policies*.

We start by showing that during a global liquidity trap governments have an incentive to intervene on the current account for prudential reasons. This is due to the same domestic aggregate demand externality described by Farhi and Werning (2016) and Korinek and Simsek (2016). That is, governments perceive that private agents overborrow in times of robust economic performance, because they do not internalize the fact that increasing savings in good times leads to higher aggregate demand and employment in the event of a future liquidity trap. Hence, governments in booming countries implement financial and fiscal policies to increase national savings and to improve the country's current account.

The fundamental insight of the paper is that these policy interventions might trigger a paradox

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[2]Though making predictions about the future is of course a challenging task, this feature of the model is consistent with the empirical analysis performed by Gourinchas and Rey (2017), suggesting that global rates are likely to remain low for a long time.

[3]Our global liquidity trap is then in line with the notion of secular stagnation as described by Hansen (1939) and Summers (2016). Both authors, in fact, refer to a state of secular stagnation as a long-lasting period characterized by low global interest rates, and by countries undergoing frequent liquidity traps, followed by fragile recoveries.

of global thrift, which is essentially an international and policy-induced version of Keynes' paradox of thrift (Keynes, 1933). By stimulating national savings and current account surpluses, governments in countries undergoing a period of robust economic performance increase the global supply of savings, depressing aggregate demand around the world. But central banks in countries stuck in a liquidity trap cannot respond to the drop in global demand by lowering their policy rate. As a consequence, the implementation of prudential current account policies by booming countries aggravates the recession in countries experiencing a liquidity trap.[4] This effect can be so strong so that well-intended prudential policy interventions might end up exacerbating the global liquidity trap rather than mitigating it.

This result sounds a note of caution on the use of prudential policies as stabilization tools during periods of weak global aggregate demand. More precisely, in our framework it is the lack of international cooperation that can give rise to a paradox of global thrift. Key to our results, indeed, is the fact that governments in booming countries do not take into account the negative effects that policies fostering their national savings and current account surpluses have on countries stuck in a liquidity trap. Our analysis, which resonates with the logic of Keynes' Plan of 1941, thus suggests that when global aggregate demand is scarce international cooperation is needed, to ensure that current account interventions by booming countries do not impart excessive negative spillovers on the rest of the world.[5]

Related literature. This paper is related to three literatures. First, the paper contributes to the emerging literature on secular stagnation in open economies (Caballero et al., 2015; Eggertsson et al., 2016). As in this literature, we study a world trapped in a global liquidity trap. This is a persistent state of affairs in which global rates are low and monetary policy is frequently constrained by the zero lower bound. Both Caballero et al. (2015) and Eggertsson et al. (2016) study two-country overlapping generations models, in which interest rates are low because of a global shortage of safe assets. Compared to these two papers, a distinctive feature of our framework is that the shortage of safe assets driving down global rates emerges from the presence of financial frictions that limits agents' ability to insure against idiosyncratic country-specific shocks. This allows us to study prudential policies, which neither Caballero et al. (2015) nor Eggertsson et al. (2016) consider, that is policy interventions that governments implement during booms to mitigate future liquidity traps.

Second, our paper is related to the work of Farhi and Werning (2016) and Korinek and Simsek (2016), who develop theories of macroprudential policy interventions based on aggregate demand externalities. In particular, these papers study optimal financial market interventions in closed or small open economies in which monetary policy is constrained by zero lower bound.[6] One

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[4] Our model thus formalizes the view that the large current account surpluses that some countries, most notably Germany, have run in the aftermath of the 2008 financial crisis might have slowed down significantly the recovery in the rest of the world (Bernanke, 2015; IMF, 2014; Krugman, 2013).

[5] Chapter 4 of Eichengreen (2008) and chapter 7 of Temin and Vines (2014) are two excellent sources on Keynes' Plan of 1941. In a nutshell, Keynes envisaged the need for international rules to contain excessive current account surpluses by booming countries, on the ground that these surpluses would depress global demand.

[6] In turn, these papers build upon Eggertsson and Krugman (2012) and Guerrieri and Lorenzoni (2017), who show that in closed economies negative financial shocks can trigger an episode of deleveraging and give rise to a

of the key insights of this literature is that benevolent governments should implement prudential financial and fiscal policies when they foresee that the zero lower bound will bind in the future.[7] We contribute to this literature by showing that, under certain conditions, in a financially integrated world prudential policies can backfire and give rise to a paradox of global thrift. Our results thus suggest that international cooperation is needed in order to fully exploit the stabilization benefits of prudential policies.

Third, our paper is related to the vast literature on international policy cooperation. For instance, Obstfeld and Rogoff (2002) and Benigno and Benigno (2003, 2006) study international monetary policy cooperation in models with nominal rigidities. In these frameworks, the gains from cooperation arise because individual countries have an incentive to manipulate their terms of trade at the expenses of the rest of the world. In our model, terms of trade are constant and independent of government policy, and hence terms of trade externalities are absent. Acharya and Bengui (2016) show that there are gains from international cooperation in the design of capital control policy during a temporary liquidity trap. Their focus is on capital control policies that governments implement in order to manipulate the exchange rate during a liquidity trap.[8] Instead, we consider ex-ante prudential policies, that is policies that governments implement to foster national savings and current account surpluses during booms, in order to mitigate future liquidity traps. Sergeyev (2016) studies optimal monetary and financial policy in a monetary union, and shows that gains from international cooperation arise because individual countries do not internalize the impact of liquidity creation by the domestic banking sector on the rest of the world. In his framework aggregate demand and pecuniary externalities interact, and fixed exchange rates constitute the fundamental constraint on monetary policy. Instead, in our model public interventions in the financial markets are purely driven by the presence of aggregate demand externalities, and our main result is that these policies can exacerbate the inefficiencies due to the zero lower bound constraint on monetary policy.

The rest of the paper is composed by five sections. Section 2 presents a simple baseline framework of an imperfectly financially integrated world with nominal rigidities. In Section 3 we characterize the laissez-faire equilibrium, and derive conditions under which the world ends up being stuck in a global liquidity trap. We then introduce, in Section 4, current account policies and describe the paradox of global thrift. In Section 5 we extend the baseline model in several directions and perform a numerical analysis. Section 6 concludes.

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recessionary liquidity trap. Benigno and Romei (2014) and Fornaro (2018), instead, study deleveraging and liquidity traps in open economies.

[7]Farhi and Werning (2012a,b, 2014) and Schmitt-Grohé and Uribe (2015) study optimal financial market interventions when the constraint on monetary policy is due to fixed exchange rates.

[8]The use of capital controls to manipulate the exchange rate during a liquidity trap is also discussed in Korinek (2017).

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2 Baseline model

In this section we present the baseline model that we use in our analysis of the global implications of current account policies. The model has two key elements. First, due to frictions on the credit markets agents cannot perfectly insure against shocks, giving rise to fluctuations in aggregate demand. Second, the presence of nominal rigidities and of the zero lower bound constraint on monetary policy implies that drops in aggregate demand can generate involuntary unemployment.

In order to deliver transparently the key message of the paper, our baseline model is kept voluntarily stylized. In Section 5 below we examine the robustness of our results by studying an extended framework that allows for a variety of features ignored in the baseline model.

2.1 Households

We consider a world composed of a continuum of measure one of small open economies indexed by $i \in [0, 1]$. Each economy can be thought of as a country. Time is discrete and indexed by $t \in \{0, 1, ...\}$. Since the presence of risk is not crucial for our results, in our baseline model there is perfect foresight. We introduce uncertainty later on in Section 5.

Each country is populated by a continuum of measure one of identical infinitely-lived households. The lifetime utility of the representative household in a generic country i is

$$\sum_{t=0}^{\infty} \beta^t \log(C_{i,t}), \tag{1}$$

where $C_{i,t}$ denotes consumption and $0 < \beta < 1$ is the subjective discount factor. Consumption is a Cobb-Douglas aggregate of a tradable good $C_{i,t}^T$ and a non-tradable good $C_{i,t}^N$, so that $C_{i,t} = (C_{i,t}^T)^\omega (C_{i,t}^N)^{1-\omega}$ where $0 < \omega < 1$.

Each household is endowed with one unit of labor. There is no disutility from working, and so households supply inelastically their unit of labor on the labor market. However, due to the presence of nominal wage rigidities to be described below, a household might be able to sell only $L_{i,t} < 1$ units of labor. Hence, when $L_{i,t} = 1$ the economy operates at full employment, while when $L_{i,t} < 1$ there is involuntary unemployment and the economy operates below capacity.

Households can trade in one-period real and nominal bonds. Real bonds are denominated in units of the tradable consumption good and pay the gross interest rate R_t. The interest rate on real bonds is common across countries, and R_t can be interpreted as the *world interest rate*. Nominal bonds are denominated in units of the domestic currency and pay the gross nominal interest rate $R_{i,t}^n$. $R_{i,t}^n$ is the interest rate controlled by the central bank, and thus can be thought of as the domestic policy rate.[9]

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[9] Alternatively, we could allow households to trade nominal bonds denominated in foreign currencies. Given the structure of the economy, however, allowing households to trade foreign nominal bonds would not affect the equilibrium allocation of the baseline model.

The household budget constraint in terms of the domestic currency is

$$P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N + P_{i,t}^T B_{i,t+1} + B_{i,t+1}^n = W_{i,t} L_{i,t} + P_{i,t}^T Y_{i,t}^T + P_{i,t}^T R_{t-1} B_{i,t} + R_{i,t-1}^n B_{i,t}^n. \qquad (2)$$

The left-hand side of this expression represents the household's expenditure. $P_{i,t}^T$ and $P_{i,t}^N$ denote respectively the price of a unit of tradable and non-tradable good in terms of country i currency. Hence, $P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N$ is the total nominal expenditure in consumption. $B_{i,t+1}$ and $B_{i,t+1}^n$ denote respectively the purchase of real and nominal bonds made by the household at time t. If $B_{i,t+1} < 0$ or $B_{i,t+1}^n < 0$ the household is holding a debt.

The right-hand side captures the household's income. $W_{i,t}$ denotes the nominal wage, and hence $W_{i,t} L_{i,t}$ is the household's labor income. Labor is immobile across countries and so wages are country-specific. $Y_{i,t}^T$ is an endowment of tradable goods received by the household. Changes in $Y_{i,t}^T$ can be interpreted as movements in the quantity of tradable goods available in the economy, or as shocks to the country's terms of trade. $P_{i,t}^T R_{t-1} B_{i,t}$ and $R_{i,t-1}^n B_{i,t}^n$ represent the gross returns on investment in bonds made at time $t-1$.

There is a limit to the amount of debt that a household can take. In particular, the end-of-period bond position has to satisfy

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t}, \qquad (3)$$

where $\kappa_{i,t} > 0$. In words, the maximum amount of debt that a household can take is equal to $\kappa_{i,t}$ units of tradable goods.

The household's optimization problem consists in choosing a sequence $\{C_{i,t}^T, C_{i,t}^N, B_{i,t+1}, B_{i,t+1}^n\}_t$ to maximize lifetime utility (1), subject to the budget constraint (2) and the borrowing limit (3), taking initial wealth $P_0^T R_{-1} B_{i,0} + R_{i,-1}^n B_{i,0}^n$, a sequence for income $\{W_{i,t} L_{i,t} + P_{i,t}^T Y_{i,t}^T\}_t$, and prices $\{R_t, R_{i,t}^n, P_{i,t}^T, P_{i,t}^N\}_t$ as given. The household's first-order conditions can be written as

$$\frac{\omega}{C_{i,t}^T} = R_t \frac{\beta \omega}{C_{i,t+1}^T} + \mu_{i,t} \qquad (4)$$

$$\frac{\omega}{C_{i,t}^T} = \frac{R_{i,t}^n P_{i,t}^T}{P_{i,t+1}^T} \frac{\beta \omega}{C_{i,t+1}^T} + \mu_{i,t} \qquad (5)$$

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \mu_{i,t} > 0 \qquad (6)$$

$$C_{i,t}^N = \frac{1-\omega}{\omega} \frac{P_{i,t}^T}{P_{i,t}^N} C_{i,t}^T, \qquad (7)$$

where $\mu_{i,t}$ is the nonnegative Lagrange multiplier associated with the borrowing constraint. Equations (4) and (5) are the Euler equations for, respectively, real and nominal bonds. Equation (6) is the complementary slackness condition associated with the borrowing constraint. Equation (7) determines the optimal allocation of consumption expenditure between tradable and non-tradable

goods. Naturally, demand for non-tradables is decreasing in their relative price $P_{i,t}^N/P_{i,t}^T$. Moreover, demand for non-tradables is increasing in $C_{i,t}^T$, due to households' desire to consume a balanced basket between tradable and non-tradable goods.

2.2 Exchange rates, interest rates and aggregate demand

In our model, monetary policy affects the real economy through its impact on households' expenditure on non-tradable goods. Before moving on, it is then useful to illustrate the channels through which the policy rate and the world interest rate affect demand for non-tradables.

Let us start by establishing a link between demand for non-tradable goods and the exchange rate. Since the law of one price holds for the tradable good we have that[10]

$$P_{i,t}^T = S_{i,t}P_t^T, \tag{8}$$

where $P_t^T \equiv \exp\left(\int_0^1 \log P_{j,t}^T dj\right)$ is the average world price of tradables, while $S_{i,t}$ is the effective nominal exchange rate of country i, defined so that an increase in $S_{i,t}$ corresponds to a nominal depreciation.

To gain intuition let us now keep $P_{i,t}^N$ and P_t^T constant, so that the nominal and the real exchange rate move together. Then equations (7) and (8) jointly imply that an exchange rate depreciation increases demand for non-tradable goods. Intuitively, when the exchange rate depreciates the relative price of non-tradables falls, inducing households to switch expenditure away from tradable goods and toward non-tradable goods.

We now relate the exchange rate to the policy and the world interest rates. Combining (4) and (5) gives a no arbitrage condition between real and nominal bonds

$$R_{i,t}^n = R_t \frac{P_{i,t+1}^T}{P_{i,t}^T}. \tag{9}$$

This is a standard uncovered interest parity condition, equating the nominal interest rate to the real interest rate multiplied by expected inflation. Since real bonds are denominated in units of the tradable good, the relevant inflation rate is tradable price inflation. Combining this expression with (8) gives

$$R_{i,t}^n = R_t \frac{S_{i,t+1}}{S_{i,t}} \frac{P_{t+1}^T}{P_t^T}.$$

Taking everything else as given, this expression implies that a drop in $R_{i,t}^n$ produces a rise in $S_{i,t}$. In words, a fall in the policy rate leads to an exchange rate depreciation, which induces households to switch expenditure out of tradable goods and toward non-tradables. Through this channel, a cut in the policy rate boosts demand for non-tradable goods. Conversely, a fall in the world interest

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[10]To derive this expression, consider that by the law of one price it must be that $P_{i,t}^T = S_{i,t}^j P_{j,t}^T$. for any i and j, where $S_{i,t}^j$ is defined as the nominal exchange rate between country i's and j's currencies, that is the units of country i's currency needed to buy one unit of country j's currency. Taking logs and integrating across j gives $P_{i,t}^T = S_{i,t}P_t^T$, where $S_{i,t} \equiv \exp\left(\int_0^1 \log S_{i,t}^j dj\right)$ and $P_t^T \equiv \exp\left(\int_0^1 \log P_{j,t}^T dj\right)$.

rate R_t generates an exchange rate appreciation which, due to its expenditure switching effect, depresses demand for non-tradables.

To capture these effects more compactly, it is useful to combine (7) and (9) into a single aggregate demand (AD) equation

$$C_{i,t}^N = \frac{R_t \pi_{i,t+1}}{R_{i,t}^n} \frac{C_{i,t}^T}{C_{i,t+1}^T} C_{i,t+1}^N, \tag{AD}$$

where $\pi_{i,t} \equiv P_{i,t}^N / P_{i,t-1}^N$. This expression is essentially an open-economy version of the New-Keynesian aggregate demand block. As in the standard closed-economy New-Keynesian model, demand for non-tradable consumption is decreasing in the real interest rate $R_{i,t}^n / \pi_{i,t+1}$ and increasing in future non-tradable consumption $C_{i,t+1}^N$. In addition, changes in the consumption of tradable goods act as demand shifters. As already explained, a higher current consumption of tradable goods increases the current demand for non-tradables. Instead, a higher future consumption of tradables induces households to postpone their non-tradable consumption, thus depressing current demand for non-tradable goods. Finally, due to the expenditure switching effect just discussed, a lower world interest rate is associated with lower demand for non-tradable consumption.

2.3 Firms and nominal rigidities

Non-traded output $Y_{i,t}^N$ is produced by a large number of competitive firms. Labor is the only factor of production, and the production function is $Y_{i,t}^N = L_{i,t}$. Profits are given by $P_{i,t}^N Y_{i,t}^N - W_{i,t} L_{i,t}$, and the zero profit condition implies that in equilibrium $P_{i,t}^N = W_{i,t}$.

We introduce nominal rigidities by assuming, in the spirit of Akerlof et al. (1996), that nominal wages are subject to the downward rigidity constraint

$$W_{i,t} \geq \gamma W_{i,t-1},$$

where $\gamma > 0$. This formulation captures in a simple way the presence of frictions to the downward adjustment of nominal wages, which might prevent the labor market from clearing. In fact, equilibrium on the labor market is captured by the condition

$$L_{i,t} \leq 1, \quad W_{i,t} \geq \gamma W_{i,t-1} \quad \text{with complementary slackness.} \tag{10}$$

This condition implies that unemployment arises only if the constraint on wage adjustment binds.

2.4 Monetary policy and inflation

We describe monetary policy in terms of targeting rules. In particular, we consider central banks that target inflation of the domestically-produced good. More formally, the objective of the central bank is to set $\pi_{i,t} = \bar{\pi}$, where $\bar{\pi}$ is the central bank's inflation target. Throughout the paper we focus on the case $\bar{\pi} > \gamma$, so that when the inflation target is attained the economy operates

at full employment ($\pi_{i,t} = \bar{\pi} \rightarrow L_{i,t} = 1$). Hence, monetary policy faces no conflict between stabilizing inflation and attaining full employment, thus mimicking the divine coincidence typical of the baseline New Keynesian model (Blanchard and Galí, 2007).[11]

The central bank runs monetary policy by setting the nominal interest rate $R_{i,t}^n$, subject to the zero lower bound constraint $R_{i,t}^n \geq 1$.[12] Monetary policy can then be captured by the following monetary policy (MP) rule[13]

$$R_{i,t}^n = \begin{cases} \geq 1 & \text{if } Y_{i,t}^N = 1, \pi_{i,t} = \bar{\pi} \\ = 1 & \text{if } Y_{i,t}^N < 1, \pi_{i,t} = \gamma, \end{cases} \qquad \text{(MP)}$$

where we have used (10) and the equilibrium relationships $W_{i,t} = P_{i,t}^N$ and $L_{i,t} = Y_{i,t}^N$. The (MP) equation captures the fact that unemployment ($Y_{i,t}^N < 1$) arises only if the central bank is constrained by the zero lower bound ($R_{i,t}^n = 1$). As we show in Appendix D, this policy is also constrained efficient as long as the central bank operates under discretion, and faces an arbitrarily small cost from deviating from its inflation target.[14]

It turns out that changes in inflation do not play any major role in our analysis. Hence, in what follows we will focus on the constant-inflation limit $\bar{\pi} \rightarrow \gamma$. This corresponds to an extremely flat Phillips curve, such that changes in unemployment do not significantly affect inflation. While this assumption is by no mean crucial for our results, it allows to streamline the exposition and simplifies the derivation of some of the results that follow.

2.5 Market clearing and definition of competitive equilibrium

Since households inside a country are identical, we can interpret equilibrium quantities as either household or country specific. For instance, the end-of-period net foreign asset position of country i is equal to the end-of-period holdings of bonds of the representative household, $NFA_{i,t} = B_{i,t+1} + B_{i,t+1}^n/P_{i,t}^T$. Throughout, we focus on equilibria in which nominal bonds are in zero net supply, so

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[11]Since only the non-tradable good is produced, we are in practice assuming that the central bank follows a policy of producer price inflation targeting. This is a common assumption in the open economy monetary literature. Another option is to consider a central bank that targets consumer price inflation. We have experimented with this possibility, and found that the results are robust to this alternative monetary policy target. The analysis is available upon request.

[12]We provide in Appendix C some possible microfoundations for this constraint. In practice, the lower bound on the nominal interest rate is likely to be slightly negative. In this paper, with a slight abuse of language, we will refer the the lower bound on $R_{i,t}^n$ as the zero lower bound. It should be clear, though, that conceptually it makes no difference between a small positive or a small negative lower bound.

[13]One could think of the central bank as setting $R_{i,t}^n$ according to the rule

$$R_{i,t}^n = \max\left(\bar{R}_{i,t}^n \left(\frac{\pi_{i,t}}{\bar{\pi}}\right)^{\phi_\pi}, 1\right),$$

where $\bar{R}_{i,t}^n$ is the value of $R_{i,t}^n$ consistent with $\pi_{i,t} = \bar{\pi}$. In the baseline model we focus on the limit $\phi_\pi \rightarrow \infty$. This means that the inflation target can be missed only if the zero lower bound constraint binds.

[14]Deviating from the inflation target could be costly for the central bank due to institutional reasons, capturing the price stability mandate characterizing central banks in most advanced countries. Alternatively one could assume, as in the standard New Keynesian model, that deviations of inflation from target are costly because they distort relative prices.

that

$$B_{i,t}^n = 0, \tag{11}$$

for all i and t. This implies that the net foreign asset position of a country is exactly equal to its investment in real bonds, i.e. $NFA_{i,t} = B_{i,t+1}$.

Market clearing for the non-tradable consumption good requires that in every country consumption is equal to production

$$C_{i,t}^N = Y_{i,t}^N. \tag{12}$$

Instead, market clearing for the tradable consumption good requires

$$C_{i,t}^T = Y_{i,t}^T + R_{t-1}B_{i,t} - B_{i,t+1}. \tag{13}$$

This expression can be rearranged to obtain the law of motion for the stock of net foreign assets owned by country i, i.e. the current account

$$NFA_{i,t} - NFA_{i,t-1} = CA_{i,t} = Y_{i,t}^T - C_{i,t}^T + B_{i,t}\left(R_{t-1} - 1\right).$$

As usual, the current account is given by the sum of net exports, $Y_{i,t}^T - C_{i,t}^T$, and net interest payments on the stock of net foreign assets owned by the country at the start of the period, $B_{i,t}(R_{t-1} - 1)$.

Finally, in every period the world consumption of the tradable good has to be equal to world production, $\int_0^1 C_{i,t}^T \, \mathrm{d}i = \int_0^1 Y_{i,t}^T \, \mathrm{d}i$. This equilibrium condition implies that bonds are in zero net supply at the world level

$$\int_0^1 B_{i,t+1} \, \mathrm{d}i = 0. \tag{14}$$

We are now ready to define a competitive equilibrium.

Definition 1 *Competitive equilibrium. A competitive equilibrium is a path of real allocations* $\{C_{i,t}^T, C_{i,t}^N, Y_{i,t}^N, B_{i,t+1}, B_{i,t+1}^n, \mu_{i,t}\}_{i,t}$, *policy rates* $\{R_{i,t}^n\}_{i,t}$ *and world interest rate* $\{R_t\}_t$, *satisfying* $(4), (6), (11), (12), (13), (14), (AD)$ *and* (MP) *given a path of endowments* $\{Y_{i,t}^T\}_{i,t}$, *a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$, *and initial conditions* $\{B_{i,0}\}_i$.

2.6 Some useful simplifying assumptions

We now make some simplifying assumptions that allow us to solve analytically the baseline model. We will relax these assumptions in Section 5, where we study the extended model.

We want to consider a world in which the global supply of saving instruments is limited, and in which borrowing constraints are tight. The simplest way to formalize this idea is to focus on the limit $\kappa_{i,t} = \kappa \to 0$ for all i and t, so that households cannot take any (significant amount of) debt. This corresponds to a zero liquidity economy, in the spirit of Werning (2015). Later on, in Section 5, we will relax this assumption and allow households to take some debt.

We also focus on a specific process for the tradable endowment. We consider a case in which there are two possible realizations of the tradable endowment: high (Y_h^T) and low (Y_l^T) with $Y_l^T < Y_h^T$. We assume that half of the countries receives Y_h^T in even periods and Y_l^T in odd periods. Symmetrically, the other half receives Y_l^T during even periods and Y_h^T during odd periods. From now on, we will say that a country with $Y_{i,t}^T = Y_h^T$ is in the high state, while a country with $Y_{i,t}^T = Y_l^T$ is in the low state. This endowment process captures in a tractable way an environment in which countries are hit by asymmetric shocks.

Finally, we are interested in studying stationary equilibria in which the world interest rate and the net foreign asset distribution are constant. This requires that the initial bond position satisfies $B_{i,0} \approx 0$ for every country i, which we assume throughout our analysis of the baseline model. Moreover, we focus on equilibria in which all the countries with the same endowment shock behave symmetrically. Hence, with a slight abuse of notation, we will sometime omit the i subscripts, and denote with a h (l) subscript variables pertaining to countries in the high (low) state.

3 Equilibrium under laissez faire

In this Section we characterize the equilibrium under laissez faire. This will serve as a benchmark against which to contrast the equilibrium with government intervention through fiscal and financial policy. We start by solving for the behavior of a single small open economy, taking the world interest rate as given. We then turn to the global equilibrium, in which the world interest rate is endogenously determined.

3.1 Small open economy

To streamline the exposition, we impose some restrictions on the world interest rate. We will later show that these restrictions emerge naturally in the global equilibrium.

Assumption 1 *The world interest rate is constant* $(R_t = R$ *for all* $t)$ *and satisfies* $\beta R < 1$.

Solving for the path of tradable consumption is straightforward. Intuitively, households smooth tradable consumption by saving in the high state, when the endowment is high, and borrowing in the low state, when the endowment is low. More precisely, from period 0 on the economy enters a stationary equilibrium in which households purchase $B_{h,t+1} = B_h \geq -\kappa \approx 0$ bonds in the high state, while the borrowing constraint binds in the low state, so that $B_{l,t+1} = B_l = -\kappa \approx 0$. The Euler equation (4) in the high state then implies

$$\frac{1}{C_h^T} \geq \beta R \frac{1}{C_l^T}, \tag{15}$$

where we have removed the time subscripts to simplify notation. Combining this expression with the resource constraint (13) and using $B_l \approx 0$ gives the optimal demand for bonds in the high state

$$B_h = \max\left\{ \frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R} \right), -\kappa \right\}. \tag{16}$$

From this expression it is then easy to solve for C_l^T and C_h^T using

$$C_h^T = Y_h^T - B_h \tag{17}$$

$$C_l^T = Y_l^T + RB_h. \tag{18}$$

Notice that, since $\beta R < 1$ and $Y_h^T > Y_l^T$, the equilibrium is such that $C_h^T > C_l^T$. Hence, fluctuations in the endowment translate into fluctuations in the consumption of tradable goods.

We now turn to the market for non-tradable goods. Equilibrium on this market is reached at the intersection of the (AD) and (MP) equations, which we rewrite here for convenience[15]

$$Y_{i,t}^N = \frac{R\bar{\pi}}{R_{i,t}^n} \frac{C_{i,t}^T}{C_{i,t+1}^T} Y_{i,t+1}^N \tag{AD}$$

$$R_{i,t}^n = \begin{cases} \geq 1 & \text{if } Y_{i,t}^N = 1 \\ = 1 & \text{if } Y_{i,t}^N < 1, \end{cases} \tag{MP}$$

where we have used the equilibrium condition $C_{i,t}^N = Y_{i,t}^N$. Let us start by taking a partial equilibrium approach, i.e. by deriving the equilibrium holding future variables constant. Figure 2 shows the AD and MP curves in the $R_{i,t}^n - Y_{i,t}^N$ space. The AD curve captures the negative relationship between aggregate demand and the policy rate, while the L-shape of the MP curve captures the aggressive response of the central bank to unemployment. In the left panel, we have drawn two AD curves. The AD_h curve refers to demand in the high state, while AD_l captures demand in the low state. The diagram shows that changes in tradable consumption act as demand shifters, so that aggregate demand is lower in the low state compared to the high state. Hence, when the economy transitions from the high to the low state the central bank decreases the policy rate to sustain aggregate demand.

The right panel of the figure shows how the equilibrium is affected by changes in the world interest rate R. The solid lines capture a world in which R is high. In this case, aggregate demand is sufficiently strong for the economy to operate at full employment in both states ($Y_h^N = Y_l^N = 1$). Instead, the dashed lines refer to a low R world. In this case, in the low state aggregate demand is so weak that monetary policy is constrained by the zero lower bound and the economy experiences unemployment ($Y_l^N < 1$).

It turns out that the insights of the partial equilibrium analysis extend to the general equilibrium. We summarize these results in the following proposition.

Assumption 2 *The inflation target $\bar{\pi}$ and the world interest rate R are such that $R\bar{\pi} > 1$.*

Proposition 1 *Small open economy under laissez faire. There exists a threshold R^*, such that if $R \geq R^*$ then $Y_h^N = Y_l^N = 1$, otherwise $Y_h^N = 1$ and $Y_l^N = R\bar{\pi} \max \left(\beta R, Y_l^T/Y_h^T \right) < 1$. R^* solves $R^*\bar{\pi} \max \left(\beta R^*, Y_l^T/Y_h^T \right) = 1$.*

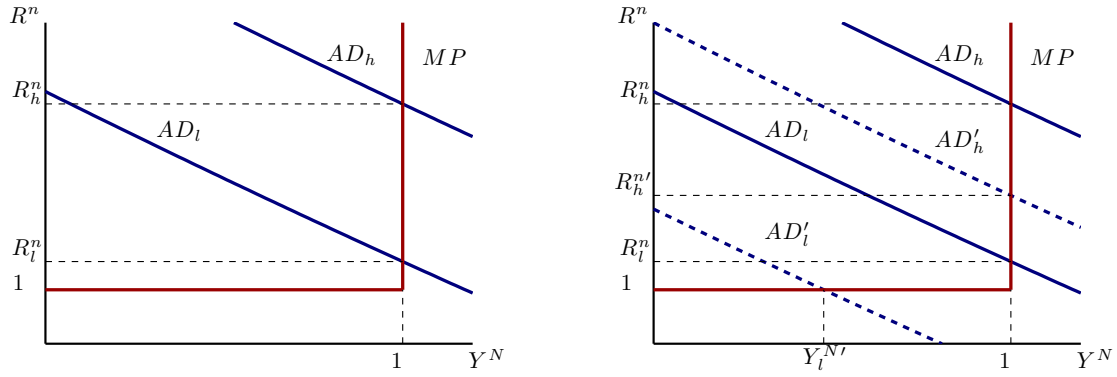[15]Recall that we are focusing on the limit $\bar{\pi} \to \gamma$.

Figure 2: Equilibrium on market for non-tradables. Right panel: high R (solid lines) vs. low R (dashed lines).

Proof. See Appendix B.1. ∎

Proposition 1 states that there exists a threshold R^* for the world interest rate, such that if $R \geq R^*$ the economy always operates at full employment. Instead, if $R < R^*$ aggregate demand in the high state is strong enough to guarantee full employment, while in the low state aggregate demand is sufficiently weak so that monetary policy is constrained by the zero lower bound and unemployment arises. The role of Assumption 2 is to guarantee that in the high state the zero lower bound constraint never binds, so that $Y_h^N = 1$. While in principle one could imagine a case in which liquidity traps have infinite duration, here we restrict attention to the more traditional case in which liquidity traps are temporary.

3.2 Global equilibrium

Recall that we are considering a world in which at each point in time half of the countries are in the high state, while the other half is in the low state. Proposition 1 thus implies that if $R \geq R^*$ world aggregate unemployment is equal to zero. Instead, if $R < R^*$ world aggregate unemployment is positive, since the zero lower bound constraint is binding in low-state countries.[16] Hence, the world interest rate R is a key determinant of global unemployment.

In a global equilibrium, R has to be such that the world bond market clears, so that (14) holds. Bonds are supplied by countries in the low state. These countries are against the borrowing constraint, and hence the supply of bonds is $-B_l = -\kappa \approx 0$. Demand for bonds comes from countries in the high state and is given by B_h. The world bond market clears when $B_h = -B_l = \kappa \approx 0$. In words, our focus on a zero liquidity economy implies that for any country equilibrium savings have to be (approximately) equal to zero. Hence, in a global equilibrium the allocation of tradable consumption corresponds to the financial autarky one, so that every country consumes

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[16]More precisely, Proposition 1 implies that if $R < R^*$ aggregate unemployment is given by

$$\int_0^1 1 - Y_{i,t}^N di = 1 - \frac{Y_l^N}{2} = 1 - \frac{R\bar{\pi} \max\left(\beta R, Y_l^T / Y_h^T\right)}{2}.$$

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its endowment ($C_h^T = Y_h^T$, $C_l^T = Y_l^T$).

The equilibrium world interest rate adjusts to ensure that countries in the high state do not want to borrow or save.[17] The value of the equilibrium world interest rate can then be found by substituting $C_h^T = Y_h^T$ and $C_l^T = Y_l^T$ in (15) holding with equality

$$R = \frac{Y_l^T}{\beta Y_h^T} \equiv R^{lf}, \tag{19}$$

where the superscript lf stands for *laissez faire*. Expression (19) relates the world interest rate to the fundamentals of the economy. Naturally, a higher discount factor β leads to a higher demand for bonds by saving countries, and thus to a lower world interest rate. Moreover, the world interest rate is decreasing in Y_h^T/Y_l^T, because a higher volatility of the endowment process increases the desire to save to smooth consumption for countries in the high state. Notice that the equilibrium interest rate satisfies $\beta R < 1$, consistent with Assumption 1. We collect these results in the following lemma.

Lemma 1 *Global equilibrium under laissez faire. In a global equilibrium $C_{h,t}^T = Y_h^T$ and $C_{l,t}^T = Y_l^T$. Moreover, under laissez faire the equilibrium world interest rate is $R_t = Y_l^T/(\beta Y_h^T) \equiv R^{lf} < 1/\beta$ for all t.*

Depending on fundamentals, the equilibrium interest rate R^{lf} might be greater or smaller than R^*, the threshold world interest rate below which the zero lower bound binds for countries in the low state.[18] We think of the case $R^{lf} < R^*$ as capturing a world trapped in a global liquidity trap. In such a world, global aggregate demand is weak and countries hit by negative shocks experience liquidity traps with unemployment. Interestingly, this state of affair can persist for an arbitrarily long period of time, as long as the fundamentals of the global economy imply that $R^{lf} < R^*$. In this sense, the model captures in a simple way the salient features of a world undergoing a period of secular stagnation, in which interest rates are low and liquidity traps frequent (Summers, 2016).

4   Current account policies and the paradox of global thrift

Since there is no disutility from working, unemployment in our model is inefficient. Hence, governments have an incentive to implement policies that limit the incidence of liquidity traps on employment. For instance, a large literature has emphasized how raising expected inflation can mitigate the inefficiencies due to the zero lower bound. However, a robust conclusion of this literature is that, in presence of inflation costs, circumventing the zero lower bound by raising inflation expectations is not an option when the central bank lacks commitment (Eggertsson and Woodford, 2003).[19]

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[17]In fact, if the borrowing constraint were to bind in the high state, all the countries in the world would want to borrow (albeit an infinitesimally small amount) preventing equilibrium from being reached.

[18]Precisely, $R^{lf} < R^*$ if $\bar{\pi} < \beta(Y_h^T/Y_l^T)^2$, otherwise $R^{lf} \geq R^*$.

[19]We extend this insight to our model in Appendix D.

In this paper we take a different route and consider the role of policies that affect agents' saving and borrowing decisions, such as fiscal or financial policies, in stabilizing aggregate demand and employment. While these policies can take a variety of forms, their common trait is that they influence national savings and, in open economies, the country's current account. Hence, we refer to them as *current account policies*.

We implement the notion of current account policies by endowing governments with the power to choose directly their country's net foreign asset position and the path of tradable consumption, as long as these do not violate the resource constraint (13) and the borrowing limit (3). Crucially, even in presence of current account policies the market for non-tradable goods clears competitively, and hence the (AD) and (MP) equations enter the government problem as implementability constraints.[20] In fact, as we will see, in our model a role for current account policies emerges precisely because the government internalizes the impact of agents' saving decisions on the non-tradable goods market.

4.1 The national planning problem

How does a government optimally intervene on the current account? We address this question by taking the perspective of a national planner that designs current account policies to maximize domestic households' welfare.[21] Importantly, the national planner does not internalize the impact of its decisions on the rest of the world. Hence, the planning allocation that we consider corresponds to the non-cooperative optimal current account policy.

As it turns out, the planning allocation might differ depending on whether the planner operates under commitment or discretion. Rather than considering both cases, throughout the paper we restrict attention to a planner that lacks commitment. We make this choice because the existing literature has shown that, if the government operates under commitment, monetary policy alone can mitigate substantially the inefficiencies due to the zero lower bound. This suggests that alternative policies, such as current account interventions, are most useful when the government operates under discretion.

Formally, we focus on Markov-stationary policy rules that are functions of the payoff-relevant state variables $(B_{i,t}, Y_{i,t}^T)$ only. Since the planner operates under discretion, it chooses its policy rules in any given period taking as given the policy rules associated with future planner's decisions. A Markov-perfect equilibrium is then characterized by a fixed point in these policy rules. Intuitively, at this fixed point the current planner does not have an incentive to deviate from future planners' policy rules, so that these rules are time consistent. In what follows, we define $\mathcal{B}(B_{i,t}, Y_{i,t}^T)$

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[20]Notice that to derive that (AD) equation we have used the no arbitrage condition between real and nominal bonds. Hence, we are effectively assuming that governments cannot influence households' decision on how to allocate their savings between the two bonds. This assumption captures a world with a high degree of capital mobility, in which it is difficult for governments to discriminate, for instance through capital controls, between domestic and foreign assets. This feature of the model resonates with the fact that capital controls have essentially been absent in advanced economies since the early 1990s (Ilzetzki et al., 2017).

[21]Later on, in Section 4.2, we show that a government can implement the planning allocation as part of a competitive equilibrium using some simple fiscal or financial policy instruments.

as the policy rule for bond holdings of future planners, while $\{\mathcal{C}^T(B_{i,t}, Y_{i,t}^T), \mathcal{Y}_N(B_{i,t}, Y_{i,t}^T)\}$ are the functions that return the values of the corresponding variables associated with the planners' policy rules.

The problem of the national planner in a generic country i can be represented as

$$V(B_{i,t}, Y_{i,t}^T) = \max_{C_{i,t}^T, Y_{i,t}^N, B_{i,t+1}} \omega \log C_{i,t}^T + (1-\omega) \log Y_{i,t}^N + \beta V(B_{i,t+1}, Y_{i,t+1}^T) \tag{20}$$

subject to

$$C_{i,t}^T = Y_{i,t}^T - B_{i,t+1} + RB_{i,t} \tag{21}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \tag{22}$$

$$Y_{i,t}^N \leq 1 \tag{23}$$

$$Y_{i,t}^N \leq C_{i,t}^T R\bar{\pi} \frac{\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)}. \tag{24}$$

The resource constraints are captured by (21) and (23). (22) implies that the government is subject to the same borrowing constraint imposed by the markets on individual households.[22] Instead, constraint (24), which is obtained by combining the (AD) and (MP) equations, encapsulates the requirement that production of non-tradable goods is constrained by private sector's demand. The functions $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)$ determine respectively consumption of tradable goods and production of non-tradable goods in period $t+1$ as a function of the country's stock of net foreign assets $(B_{i,t+1})$ and the endowment of tradables $(Y_{i,t+1}^T)$ at the beginning of next period. Since the current planner cannot make credible commitments about its future actions, these variables are not into its direct control. However, the current planner can still influence these quantities through its choice of net foreign assets. In what follows, we focus on equilibria in which these functions are differentiable. Moreover, we will restrict attention to equilibria in which $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1})$ is non-decreasing in $B_{i,t+1}$, that is in which tradable consumption is non-decreasing in start-of-period wealth. We make this mild assumption to simplify some of the proofs.

Notice that, since each country is infinitesimally small, the domestic planner takes the world interest rate R as given. This feature of the planning problem synthesizes the lack of international coordination in the design of current account policies.

The first order conditions of the planning problem can be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{C_{i,t}^T} + \bar{v}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} \tag{25}$$

$$\frac{1-\omega}{Y_{i,t}^N} = \bar{\nu}_{i,t} + \bar{v}_{i,t} \tag{26}$$

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[22]To write this constraint we have used the equilibrium condition $B_{i,t+1}^n = 0$. It is straightforward to show that allowing the government to set $B_{i,t+1}^n$ optimally would not change any of the results.

$$\bar{\lambda}_{i,t} = \beta R \bar{\lambda}_{i,t+1} + \bar{\mu}_{i,t} + \bar{v}_{i,t} Y_{i,t}^N \left[\frac{\mathcal{Y}_B^N(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)} - \frac{\mathcal{C}_B^T(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)} \right] \tag{27}$$

$$B_{i,t+1} \geq -\kappa_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{28}$$

$$Y_{i,t}^N \leq 1 \quad \text{with equality if} \quad \bar{\nu}_{i,t} > 0 \tag{29}$$

$$Y_{i,t}^N \leq C_{i,t}^T R \bar{\pi} \frac{\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)} \quad \text{with equality if} \quad \bar{v}_{i,t} > 0, \tag{30}$$

where $\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{v}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints (21), (22), (23) and (24), while $\mathcal{Y}_B^N(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{C}_B^T(B_{i,t+1}, Y_{i,t+1}^T)$ are the partial derivatives respectively of $\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)$ with respect to $B_{i,t+1}$.

It is useful to combine (25) and (27) to obtain

$$\frac{1}{C_{i,t}^T} \left(\omega + \bar{v}_{i,t} Y_{i,t}^N \right) = \frac{\beta R}{C_{i,t+1}^T} \left(\omega + \bar{v}_{i,t+1} Y_{i,t+1}^N \right) + \bar{\mu}_{i,t}$$
$$+ \bar{v}_{i,t} Y_{i,t}^N \left[\frac{\mathcal{Y}_B^N(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)} - \frac{\mathcal{C}_B^T(B_{i,t+1}, Y_{i,t+1}^T)}{\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)} \right]. \tag{31}$$

This is the planner's Euler equation. Comparing this expression with the households' Euler equation (4), it is easy to see that the marginal benefit from a rise in $C_{i,t}^T$ perceived by the planner differs from households' whenever $\bar{v}_{i,t} > 0$ in any period t, that is when the zero lower bound constraint binds. This happens because, contrary to atomistic households, the planner internalizes the impact that financial decisions have on output when the central bank is constrained by the zero lower bound.

We are now ready to define an equilibrium with current account policies.

Definition 2 Equilibrium with current account policies. *An equilibrium with current account policies is a path of real allocations $\{C_{i,t}^T, Y_{i,t}^N, B_{i,t+1}, \bar{\mu}_{i,t}, \bar{\nu}_{i,t}, \bar{v}_{i,t}\}_{i,t}$ and world interest rate $\{R_t\}_t$, satisfying (14), (21), (26), (28), (29), (30) and (31) given a path of endowments $\{Y_{i,t}^T\}_{i,t}$, a path for the borrowing limits $\{\kappa_{i,t}\}_{i,t}$, and initial conditions $\{B_{i,0}\}_i$. Moreover, the functions $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)$ have to be consistent with the national planners' decision rules.*

4.2 Current account policies in a small open economy

Under the simplifying assumptions stated in Section 2.6, it is possible to solve analytically for the equilibrium with current account policies. We start by considering a single small open economy, and characterize the solution to the national planning problem as a function of the world interest rate.

Proposition 2 National planner allocation. *Consider stationary solutions to the national planning problem. Define $R^{**} = \omega Y_l^T/(\beta Y_h^T)$ and $\tilde{R} \equiv (\omega/(\bar{\pi}\beta))^{1/2}$. The planning allocation is such that $Y_h^N = 1$, $Y_l^N = Y_l^{Np}$, $B_h = B_h^p$ and $B_l = 0$, where Y_l^{Np} and B_h^p are defined as*

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$$\begin{cases} B_h^p = -\kappa \approx 0, Y_l^{Np} = R\bar{\pi}Y_l^T/Y_h^T < 1 & \text{if} \qquad R < R^{**} \\ B_h^p = \frac{\beta}{\omega+\beta}\left(Y_h^T - \frac{\omega Y_l^T}{\beta R}\right), Y_l^{Np} = R^2\bar{\pi}\beta/\omega < 1 & \text{if } R^{**} \le R < \tilde{R} \\ B_h^p = \frac{Y_h^T - R\bar{\pi}Y_l^T}{1+R^2\bar{\pi}}, Y_l^{Np} = 1 & \text{if } \tilde{R} \quad \le R < R^* \\ B_h^p = \max\left\{\frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right), 0\right\}, Y_l^{Np} = 1 & \text{if } R^* \quad \le R. \end{cases} \tag{32}$$

Moreover, $\bar{\mu}_h > 0$ if $R < R^{**}$ or $R^* \le R < Y_l^T/(Y_h^T\beta)$, otherwise $\bar{\mu}_h = 0$.

Proof. See Appendix B.2. ■

Corollary 3 *Consider a small open economy facing the world interest rate R. If $R^{**} < R < R^*$ both Y_l^N and B_h are higher under the national planner allocation than under laissez faire, otherwise the two allocations coincide.*

Corollary 3 provides two results. First, if $R \ge R^*$, so that the zero lower bound never binds, the planner chooses the same path for tradable consumption and bonds that households would choose under laissez faire. This result highlights the fact that in our simple model there are no incentives for the domestic government to intervene on the current account if monetary policy is not constrained by the zero lower bound.

Second, if the zero lower bound binds when the economy is in the low state ($R < R^*$), the government intervenes to increase the current account surplus while the economy is in the high state.[23] To understand the logic behind this result, consider a case in which the economy operates below potential in the low state, so that

$$Y_l^N = R\bar{\pi}C_l^T/C_h^T, \tag{33}$$

where we have used the fact that Proposition 2 implies $Y_h^N = 1$. Now imagine that the government implements a policy that leads to an increase in B_h, and thus in the country's current account surplus while the economy is booming. Households now enter the low state with higher wealth and, since they are borrowing constrained, this leads to a rise in C_l^T. But the rise in C_l^T also boosts demand for non-tradables in the low state.[24] In turn, since the central bank is constrained by the zero lower bound, higher demand for non-tradables leads to higher output and employment. Graphically, as illustrated by Figure 3, an increase in B_h makes the AD_l curve shift right to AD'_l, and generates a rise in Y_l^N.[25]

The need for policy intervention arises because of the presence of an aggregate demand externality, as in Farhi and Werning (2016) and Korinek and Simsek (2016). Atomistic households, indeed,

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[23]This is true as long as the borrowing constraint does not bind while the economy is in the high state. As shown in Proposition 32 the borrowing constraint binds in the high state if $R < R^{**}$. This can never be the case, however, in a global equilibrium.

[24]In a stationary equilibrium there is also a second effect. Indeed, the rise in B_h lowers C_h^T, i.e. tradable consumption in the high state. This effect also contributes to the rise in demand for non-tradables when the economy is in the low state.

[25]One can show that in our baseline model, as long as $Y_l^N < 1$, changes in C_l^T/C_h^T do not alter aggregate demand in the high state, and hence the AD_h curve does not move after the increase in B_h.
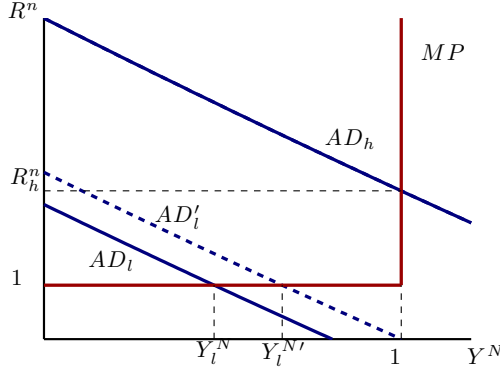
Figure 3: Response to increase in B_h. Solid lines refer to low B_h, dashed lines refer to high B_h.

take aggregate demand and employment as given, and do not internalize the impact of tradable consumption decisions on aggregate demand and production of non-tradable goods. Interestingly, current account interventions have a prudential flavor. In fact, the government intervenes to increase national savings and the current account surplus in the high state, when the economy is booming, to mitigate the drop in employment associated with future liquidity traps occurring when the economy transitions toward the low state.

Before moving on, it is useful to spend some words on the instruments that a government needs to decentralize the planning allocation. One possibility is to give to the government the power to impose a borrowing limit tighter than the market one. Under this financial policy, (3) is replaced by

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\min\left\{\kappa_{i,t}, \kappa_{i,t}^g\right\},$$

where $\kappa_{i,t}^g$ is the borrowing limit set by the government. The government can implement the planning allocation characterized in Proposition 2 as part of a competitive equilibrium by setting $\kappa_h^g = -B_h^p \leq \kappa$ and $\kappa_l^g = \kappa$. Intuitively, to decentralize the planning allocation with financial policy the government should tighten households' access to credit when the economy is in the high state.

Alternatively, the planning allocation could be decentralized using fiscal policy. Consider a case in which the government can levy lump-sum taxes on households $T_{i,t}$, to be paid with tradable goods, and use the proceeds to purchase foreign bonds. The government budget constraint is $B_{i,t+1}^g = T_{i,t} + R_{t-1}B_{i,t}^g$, where $B_{i,t}^g$ denotes the stock of foreign bonds held by the government at the start of period t.[26] Under these assumptions, equation (13) is replaced by

$$C_{i,t}^T = Y_{i,t}^T + R_{t-1}\left(B_{i,t} + B_{i,t}^g\right) - \left(B_{i,t+1} + B_{i,t+1}^g\right).$$

The planning allocation characterized in Proposition 2 can be implemented as part of a competitive equilibrium with fiscal policy by setting $B_h^g = B_h^p + \kappa$ and $B_l^g = 0$. In words, the government accumulates foreign assets while the economy is booming, and rebates them to households when

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[26]To prevent governments from circumventing the private borrowing limit, we also assume that governments cannot sell bonds to foreign agents, i.e. $B_{i,t+1}^g \geq 0$.

the economy is in a liquidity trap. This simple form of fiscal policy is effective because the presence of the borrowing limit prevents households from undoing asset accumulation by the government through increases in private borrowing.

Taking stock, the government can use simple forms of financial and fiscal policy to implement the planning allocation. In particular, in our model a government can attain an increase in the country's current account surplus either by tightening financial regulation or through a rise in the fiscal surplus. Hence, prudential financial and fiscal policies are the natural counterpart of the current account policy outlined in Proposition 2.

In this section, we have essentially extended the insights from the literature on aggregate demand externalities and prudential policy interventions to our setting (Farhi and Werning, 2016; Korinek and Simsek, 2016). In particular, we have shown that governments have an incentive to implement prudential current account policies to complement monetary policy, when the monetary authority is constrained by the zero lower bound. As in Farhi and Werning (2016), when implemented by a single small open economy current account policies will lead to higher average output and welfare. While this point is well understood, little is known about what happens when current account policies are implemented by a significantly large group of countries. We tackle this issue next.

4.3 Global equilibrium with current account policies

We now characterize the global equilibrium when all the countries implement the current account policy described in Proposition 2. Our key result is that, once general equilibrium effects are taken into account, government interventions on the international credit markets can backfire by exacerbating the global liquidity trap and give rise to a paradox of global thrift.

Given our focus on the zero liquidity limit, in a global equilibrium all the countries must hold approximately zero bonds. It follows that, just as in the laissez-faire equilibrium, the allocation of tradable consumption corresponds to the autarky one ($C_l^T = Y_l^T$ and $C_h^T = Y_h^T$). Hence, when current account policies are implemented on a global scale governments' efforts to alter the path of tradable consumption are ineffective.

This does not, however, mean that current account policies do not have any impact. Indeed, the following proposition provides a striking result: current account interventions exacerbate the global liquidity trap, and have a negative impact on global output and welfare.

Proposition 3 *Global equilibrium with current account policies. Suppose that $R^{lf} < R^*$. Then $R^p < R^{lf}$, where R^p is the world interest rate that clears the global credit markets when governments implement current account policies. Moreover, for every country output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one.*

Proof. See Appendix B.3. ∎

Perhaps the best way to gain intuition about this result is through a diagram. The left panel of Figure 4 displays the demand for bonds by countries in the high state (B_h) and supply of bonds
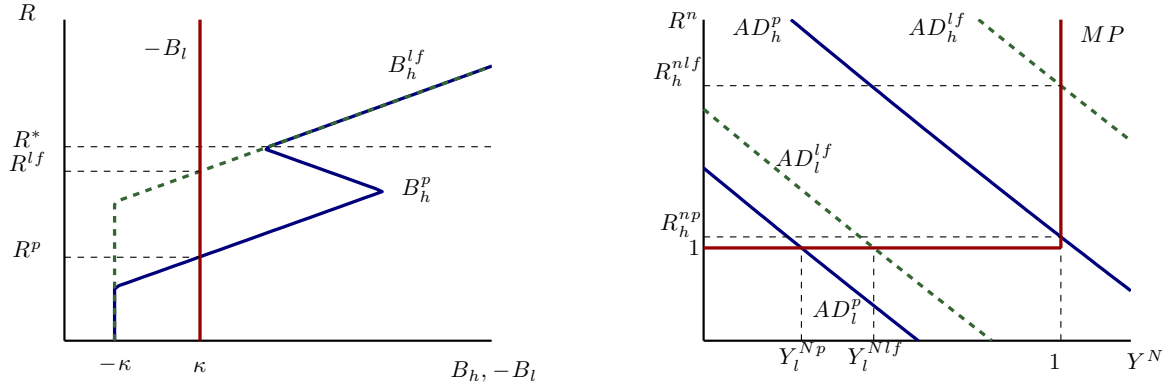
20

Figure 4: Impact of current account policies during a global liquidity trap.

by countries in the low state ($-B_l$), as a function of the world interest rate (R). The solid line B_h^p corresponds to the demand for bonds when governments intervene on the international credit markets, while the dashed line B_h^{lf} displays the demand for bonds under laissez faire. Notice that for $R^{**} < R < R^*$ the demand for bonds under current account policy is higher than under laissez faire. Indeed, this is the range of R for which governments in high-state countries intervene to increase the current account surplus.[27] The supply of bonds, instead, does not depend on whether governments intervene. In fact, in both cases countries in the low state end up being borrowing constrained, and the supply of bonds is $-B_l = \kappa$.

The equilibrium world interest rate is found at the intersection of the B_h and $-B_l$ schedules. The diagram shows that $R^p < R^{lf}$, meaning that the equilibrium with current account interventions features a lower world interest rate compared to the laissez-faire one. To understand this result, consider a world with no current account interventions. Now imagine that governments in countries in the high state start intervening to increase their current account surpluses. This generates an increase in the global demand for bonds. But world bonds supply is fixed because countries in the low state are borrowing constrained. To restore equilibrium the world interest rate has to fall, so as to bring back the demand for bonds to its equilibrium value of κ.

The right panel of Figure 4 shows how the market for non-tradable goods adjusts to the fall in the world interest rate caused by the implementation of current account policies. A lower world interest rate depresses demand for non-tradable consumption across the whole world. Graphically, this is captured by the fact that the AD curves with current account policies (solid lines) lie to the left of the ones under laissez-faire (dashed lines). Due to the zero lower bound constraint, central banks in low-state countries cannot respond to the drop in aggregate demand by reduc-

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[27]The non-monotonicity of B_h^p arises for the following reason. According to Proposition 2, when $\tilde{R}^{**} \leq R < R^*$ the national planners choose a value of B_h such that Y_l^N is exactly equal to 1. In words, governments intervene to increase the current account during booms so that the economy operates at full employment during busts. But a lower world interest rate implies that a country need to save more while in the high state to keep the economy at full employment in the low state. Hence, for $\tilde{R}^{**} \leq R < R^*$ the demand for bonds by countries in the high state is decreasing in R. Once R gets too low, precisely for $R < \tilde{R}$, it becomes too costly for the government to increase B_h so as to always keep the economy at full employment. In this case, the standard logic applies and demand for bonds becomes increasing in the world interest rate.
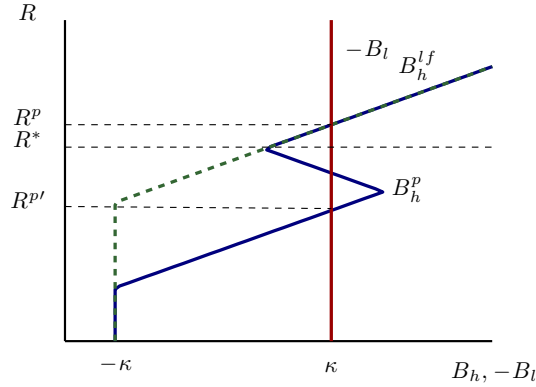
Figure 5: Multiple equilibria under current account policies.

ing the policy rate. Through this channel, current account interventions in booming high-state countries exacerbate the recession in low-state countries stuck in a liquidity trap. As a result, the implementation of current account policies produces a drop in global output and welfare.[28]

This is the essence of the *paradox of global thrift*. Due to their general equilibrium impact on global aggregate demand, prudential current account policies aiming at mitigating the output and welfare losses associated with liquidity traps end up exacerbating them.

We now consider the impact of current account interventions when fundamentals are such that $R^{lf} \geq R^*$. This corresponds to a case in which, under laissez faire, the world interest rate is sufficiently high so that the zero lower bound never binds.

Proposition 4 *Multiple equilibria with current account policies. Suppose that $R^{lf} \geq R^*$. Then $R^p = R^{lf}$ is an equilibrium with current account policies. This equilibrium is isomorphic to the laissez-faire one. However, if $R^{**} < R^*$, there exists at least another equilibrium with current account policies associated with a world interest rate $R^{p\prime} < R^*$. This equilibrium features lower output and welfare than the laissez-faire one.*

Proof. See Appendix B.4. ∎

One might be tempted to conclude that if $R^{lf} \geq R^*$ then governments will not intervene on the international credit markets, and the equilibrium with current account policies will coincide with the laissez-faire one. Indeed, Proposition 4 states that this is a possibility. However, Proposition 4 also states that there might be other equilibria, characterized by current account interventions and associated with global liquidity traps. Hence, the fact that fundamentals are sufficiently good to rule out a global liquidity trap under laissez faire does not exclude the possibility of a global liquidity trap when governments intervene on the current account. This result is illustrated by Figure 5, which shows that multiple intersections between the B_h^p and $-B_l$ curves are possible.

To gain intuition about this result, consider that governments' actions depend on their expectations about the future path of the world interest rate. This happens because the zero lower

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[28]To see why welfare is lower under the non-cooperative policy compared to laissez faire, consider that current account policies do not affect the equilibrium path of tradable consumption. It follows that their impact on welfare is fully captured by the drop in non-tradable output and consumption.

bound binds only if the world interest rate is sufficiently low. For instance, consider a case in which governments expect that the world interest rate will never fall below R^*. In this case, governments expect that the zero lower bound will never bind and hence do not intervene. Since we are focusing on the case $R^{lf} \geq R^*$, in absence of policy interventions the zero lower bound will indeed never bind, confirming the initial expectations. But now think of a case in which governments anticipate that the world interest rate will always be below R^*, so that the zero lower bound is expected to bind in countries the low state. Then governments in high-state countries will start intervening on the current account in an attempt to reduce future unemployment. These interventions will increase the global supply of savings above its value under laissez faire, putting downward pressure on the world interest rate. If $R^{**} < R^*$ holds, the resulting drop in the interest rate is sufficiently large so that $R < R^*$, validating governments' initial expectations. Thus, expectations of a future global liquidity trap might generate a global liquidity trap in the present.

We have seen that current account interventions, while being desirable from the point of view of a single country, can lead to perverse outcomes once their general equilibrium effects are taken into account. First, current account policies implemented during a global liquidity trap lead to a drop in global output and welfare. Second, current account policies might open the door to global liquidity traps purely driven by pessimistic expectations. Since all these general equilibrium effects are mediated by the world interest rate, which national governments take as given, the perverse effects associated with current account policies are not internalized by governments.[29] Our results thus suggest that international cooperation is needed during a global liquidity trap, in order to limit the negative spillovers arising from unilateral current account interventions. Otherwise, self-oriented interventions on the current account might backfire by triggering a paradox of global thrift.

So far we have drawn conclusions based on an admittedly stylized model. While this model is useful to derive intuition, one might wonder whether these results are driven by some of the specific assumptions that we have made. In what follows we consider a more realistic framework, and show that paradox-of-global-thrift effects can arise even in this more general setting.

5   Extended model and numerical analysis

In this section, we consider an extended version of the baseline model and perform a simple calibration exercise. To be clear, the objective of this exercise is not to provide a careful quantitative evaluation of the framework, or to replicate any particular historical event. Rather, our aim is to show that our key results do not depend on the simplifying assumptions characterizing the baseline

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[29]One might wonder what would happen in a framework in which countries are large enough, so that governments take into account the impact of their policy decisions on the world interest rate. Though a formal analysis of this case is beyond the scope of this paper, we conjecture that our key results would survive in this alternative setting. In our model, in fact, prudential current account policies backfire because governments in booming countries do not internalize the impact of their current account interventions on welfare in countries experiencing a recession. Hence, the logic behind our results should survive, as long as one considers self-oriented national governments that ignore the impact of their policy decisions on welfare in the rest of the world.

model.

5.1 Extended model

For our numerical exercise we enrich the baseline framework in three dimensions. First, we consider more general households' preferences. Second, we depart from the zero liquidity limit, and allow countries to take positive amounts of debt. Third, we introduce uncertainty, in the form of idiosyncratic tradable endowment and financial shocks. In the interest of space here we provide an informal description of the model, while the details can be found in Appendix E.

We start by generalizing households' utility function to

$$U\left(C_{i,t}, L_{i,t}\right) = \frac{C_{i,t}^{1-\sigma} - 1}{1 - \sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1 + \eta},$$

where $\sigma > 0$, $\chi > 0$ and $\eta \geq 0$. Hence, utility from consumption takes a standard CRRA form and households experience disutility from labor effort. Moreover, the consumption aggregator is now defined as

$$C_{i,t} = \left(\omega\left(C_{i,t}^T\right)^{1-\frac{1}{\xi}} + (1-\omega)\left(C_{i,t}^N\right)^{1-\frac{1}{\xi}}\right)^{\frac{\xi}{\xi-1}}, \tag{34}$$

where $0 < \omega < 1$ and $\xi > 0$. These functional forms are standard in the literature on monetary policy in open economies (Uribe and Schmitt-Grohé, 2017).

We depart from the zero liquidity limit in two directions. First, we allow our model economies to run imbalances against the rest of the world. In particular, we replace the world bond market clearing condition (14) with

$$\int_0^1 B_{i,t+1} di = B^{rw},$$

where B^{rw} captures a fixed supply of bonds from the rest of the world.[30] Moreover, we replace the borrowing limit (3) with

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t} + \theta\left(R_{t-1}B_{i,t} + R_{i,t-1}^n \frac{B_{i,t}^n}{P_{i,t}^T}\right),$$

where $\kappa_{i,t} \geq 0$ and $\theta \geq 0$. In our numerical simulations we will consider the case $\kappa_{i,t} > 0$, so that countries will be able to accumulate positive amounts of debt. We will also, following Justiniano et al. (2015) and Guerrieri and Iacoviello (2017), introduce inertia in the borrowing limit by setting $\theta > 0$. One reason to consider an inertial adjustment of the borrowing limit is the fact that the model features only debt contracts that last one period, which in our numerical simulations corresponds to one year. In reality, however, debt typically takes longer maturities. This formalization of the borrowing constraint captures in a tractable way the fact that long-term debt allows agents to adjust gradually to episodes of tight access to credit.

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[30]In Appendix G we allow the bond supply from the rest of the world to react to changes in the world interest rate.

Finally, the extended model features two different sources of idiosyncratic uncertainty. We model idiosyncratic fluctuations in the tradable good endowment by assuming that $Y_{i,t}^T$ follows the log-normal AR(1) process

$$\log\left(Y_{i,t}^T\right) = \rho \log\left(Y_{i,t-1}^T\right) + \epsilon_{i,t},$$

where $\epsilon_{i,t}$ is normally distributed with zero mean and standard deviation σ_ϵ. The shock $\epsilon_{i,t}$ is uncorrelated across countries, and hence the world endowment of tradable goods is constant over time.

Countries are also subject to financial shocks, modeled as idiosyncratic fluctuations in the borrowing limit $\kappa_{i,t}$. Our aim is to capture economies that alternate between tranquil times and financial crises. The simplest way to formalize this notion is to assume that $\kappa_{i,t}$ transitions between two values, κ_h and κ_l with $\kappa_h > \kappa_l$, according to a first-order Markov process. As we will see periods of tight access to credit, i.e. periods in which $\kappa_{i,t} = \kappa_l$, will trigger dynamics similar to a financial crisis event in countries featuring a significant stock of external debt.

5.2 Parameters

The extended model cannot be solved analytically, and we study its properties using numerical simulations. We employ a global solution method, described in Appendix F, in order to deal with the nonlinearities involved by the occasionally binding borrowing and zero lower bound constraints.

One period corresponds to one year. We set the coefficient of relative risk aversion to $\sigma = 2$, the elasticity of substitution between tradable and non-tradable goods to $\xi = 0.5$, and the share of tradable goods in consumption expenditure to $\omega = 0.25$, in line with the international macroeconomics literature. The inverse of the Frisch elasticity of labor supply η is set equal to 2.2, as in Galí and Monacelli (2016). We normalize $\chi = 1 - \omega$, which implies that equilibrium labor at full employment is equal to 1.[31]

The next set of parameters is selected to match some salient features characterizing advanced economies in the aftermath of the 2008 global financial crisis.[32] We set the discount factor to $\beta = 0.988$, so that under laissez faire the steady-state world interest rate R^{lf} is equal to 1.007. This target captures the low interest rate environment that has characterized advanced economies in the post-crisis years. In fact, 0.7% corresponds to the average real world interest rate over the period 2009-2015, estimated as in King and Low (2014). We calibrate B^{rw} and $\bar{\pi}$ using data from a sample of advanced economies.[33] We set B^{rw}, the bond supply from the rest of the world, to reproduce the fact that advanced economies have been in the recent past net debtors toward the

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[31]As shown in Appendix E, in absence of nominal wage rigidities equilibrium labor in the extended model would be constant. This property arises due the fact that production takes place only in the non-tradable sector and the parametric assumption $\sigma = 1/\xi$, which implies that utility is separable in consumption of tradable and non-tradable goods.

[32]Appendix H provides a detailed description of the data sources and the procedures we employed to calibrate the model.

[33]Our sample of advanced economies is composed of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

Table 1: Parameters

	Value	Source/Target
Risk aversion	$\sigma = 2$	Standard value
Elasticity consumption aggr.	$\xi = 0.5$	Standard value
Tradable share in expenditure	$\omega = 0.25$	Standard value
Frisch elasticity of labor supply	$1/\eta = 1/2.2$	Galí and Monacelli (2016)
Labor disutility coefficient	$\chi = 1 - \omega$	Normalization
Discount factor	$\beta = 0.988$	$R^{lf} = 0.7\%$
Bond supply r.o.w.	$B^{rw} = -0.376$	$B^{rw}/\int_0^1 GDP_{i,t}di = -9.4\%$
Inflation target	$\bar{\pi} = 1.0125$	Average core inflation
Tradable endowment process	$\rho = 0.87, \sigma_{Y^T} = 0.056$	Estimate for advanced economies
Prob. negative financial shock	$p(\kappa_l|\kappa_h) = 0.125$	1% prob. financial crisis
Persistence negative financial shock	$p(\kappa_l|\kappa_l) = 0.2$	5 years crisis duration
Tight credit regime	$\kappa_l = 0$	$Corr(CA/GDP, GDP) = -0.21$
	$\theta = 0.9$	mimics 10y debt maturity

rest of the world.[34] In particular, we set B^{rw} so that under laissez-faire the net debt position of our model economies is equal to 9.4% of their aggregate GDP. This corresponds to the aggregate net debt-to-GDP ratio of our sample countries, averaged over the period 2009-2015. $\bar{\pi}$ is chosen to match the average core inflation rate experienced by our sample countries between 2009 and 2015. This target implies $\bar{\pi} = 1.0125$.

We calibrate the tradable endowment process based on data on the cyclical component of tradable output in our sample countries. We identify tradable output in the data as per capita GDP in agriculture, forestry, fishing, mining, and manufacturing at constant prices. The sample period goes from 1970 to 2015. Since our model abstracts from aggregate shocks, we control for global movements in tradable output by subtracting, for each year, aggregate per-capita tradable output from the country-level series. We then extract the cyclical component from the resulting series by subtracting a country-specific log-linear trend. The first order autocorrelation ρ and the standard deviation σ_{Y^T} of the tradable endowment process are set respectively to 0.87 and 0.056, to match their empirical counterparts. In the computations, we approximate the tradable endowment process with the quadrature procedure of Tauchen and Hussey (1991) using 7 nodes.

We are left to calibrate the parameters governing the borrowing limit and the financial shocks. We are interested in capturing economies that alternate between tranquil times, characterized by abundant access to credit, and financial crisis episodes triggered by sudden stops in capital inflows. We start by setting κ_h to a value high enough so that the borrowing constraint never binds when $\kappa_{i,t} = \kappa_h$. The parameters κ_l and θ, joint with the transition probabilities $p(\kappa_l|\kappa_h)$ and $p(\kappa_l|\kappa_l)$, thus determine how often the borrowing constraint binds, as well as agents' ability to smooth consumption in response to endowment shocks.

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[34]Indeed, in recent years advanced economies have been net recipients of capital inflows from emerging countries. As is well known, see for instance Bernanke (2005), a large driver of these capital flows has been the accumulation of reserves by central banks in emerging markets. It is not clear how to model the reaction of these flows to changes in the world interest rate. For this reason, in our baseline model we have opted for the simplest assumption of an inelastic supply of funds from the rest of the world. In Appendix G, however, we examine the robustness of our results to the presence of an elastic supply of funds from rest-of-the-world countries.
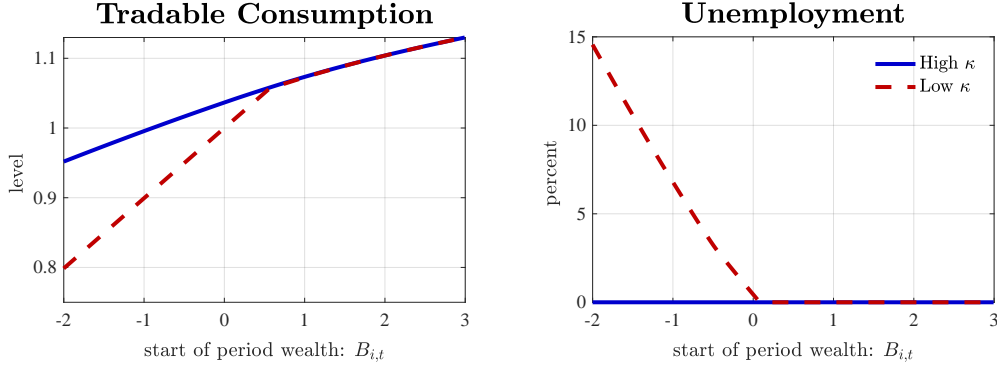
Figure 6: Policy functions in the laissez-faire steady state.

We set the probability of an adverse financial shock $p(\kappa_l|\kappa_h)$ and its persistence $p(\kappa_l|\kappa_l)$ to target the frequency and duration of financial crises in our sample countries. We follow Bianchi and Mendoza (2018) and define a financial crisis as a sharp improvement in the trade balance, capturing unusually large drops in foreign financing. Different from Bianchi and Mendoza (2018), since our model abstract from global financial shocks, to identify financial crisis episodes in the data we control for time fixed effects.[35] The resulting annual frequency of financial crises is 1% and their average duration is 5 years. We match these statistics by setting $p(\kappa_l|\kappa_h) = 0.125$ and $p(\kappa_l|\kappa_l) = 0.2$.

To choose values for θ and κ_l we employ the following strategy. To set θ we exploit the fact that this parameter corresponds to the fraction of debt that can be rolled over every period, irrespective of whether the borrowing constraint binds or not. Hence, drawing a parallel with long-term debt, $1 - \theta$ can be interpreted as the fraction of debt maturing in a given period. Following this logic we set $\theta = 0.9$ to mimic an average debt maturity of 10 years, close to the average US households' debt maturity reported by Jones et al. (2017).[36] To set κ_l we target the negative correlation between current account and GDP characterizing our sample countries. In fact, in absence of financial frictions our model would generate a counterfactual positive correlation between these two variables, since agents would smooth consumption by saving in good times and borrowing during downturns. As financial shocks become more severe, i.e. as κ_l falls, the correlation between current account and GDP implied by the model falls, until it eventually turns negative. Given $\theta = 0.9$, setting $\kappa_l = 0$ generates a correlation between the current account-to-GDP ratio and GDP of -0.21, equal to its empirical counterpart.

5.3 Debt and liquidity traps under laissez faire

Before discussing the impact of current account policies, in this section we briefly describe the steady-state equilibrium under laissez faire. We will show that a country that has accumulated a high stock of debt is at risk of experiencing liquidity traps characterized by severe rises in

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[35]See Appendix H for a detailed description of the procedure that we use to identify financial crisis events in the data.

[36]Following Jones et al. (2017) and interpreting θ as the fraction of debt that matures every period, average debt maturity D can be written as $D = R/(\theta + R - 1)$.
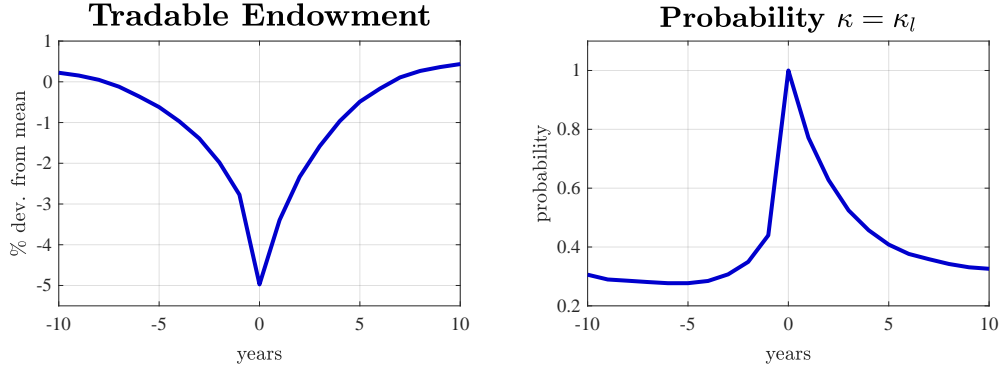
Figure 7: Liquidity trap events: tradable endowment and financial shocks.

unemployment.

Figure 6 displays the optimal choices for tradable consumption and unemployment as a function of $B_{i,t}$, i.e. the country's stock of wealth at the start of the period. The solid lines refer to countries with abundant access to credit $(\kappa_{i,t} = \kappa_h)$, while the dashed lines correspond to countries hit by negative financial shocks $(\kappa_{i,t} = \kappa_l)$.[37] The left panel of Figure 6 shows that, as it is natural, tradable consumption is increasing in wealth. Moreover, the figure shows that high-debt countries hit by negative financial shocks experience sharp falls in tradable consumption, triggered by the binding borrowing constraint. Taking stock, tradable consumption is low in high-debt countries, especially when these are hit by negative financial shocks.

The right panel of Figure 6 shows that high-debt countries with tight access to credit are exactly the ones experiencing high unemployment. To understand this result consider that, just as in the baseline model, demand for non-tradable consumption is increasing in consumption of tradable goods. Hence, the combination of high debt and tight access to credit depresses both consumption of tradable goods and demand for non-tradables. Low demand for non-tradables, in turn, pushes the policy rate against the zero lower bound and the economy into a recessionary liquidity trap. This explains why high-debt countries are exposed to the risk of sharp rises in unemployment in the event of a negative financial shock.

Figures 7 and 8 provide a snapshot of the liquidity trap events generated by the model. To construct these figures, we simulated the behavior of a country under laissez faire for a large number of periods and collected all the liquidity trap events. We then took averages of several macroeconomic indicators across all these events, centering each episode around the period associated with the peak in unemployment.[38] Figure 7 displays the average path of the tradable endowment and financial shocks, while the solid lines in Figure 8 illustrate the dynamics of GDP, tradable consumption, current account and unemployment.

Large rises in unemployment are preceded by low realizations of the tradable endowment shock,

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[37]Both policy functions are conditional on $Y_{i,t}^T$ being equal to its mean value.

[38]More precisely, we say that a country is in a liquidity trap in a given period t if $L_{i,t} < 1$, that is if unemployment is positive. We then define the unemployment peak during a liquidity trap as the period in which unemployment is at its highest value compared to the 10 periods before and after. The period associated with the unemployment peak corresponds to period 0 in Figures 7 and 8.
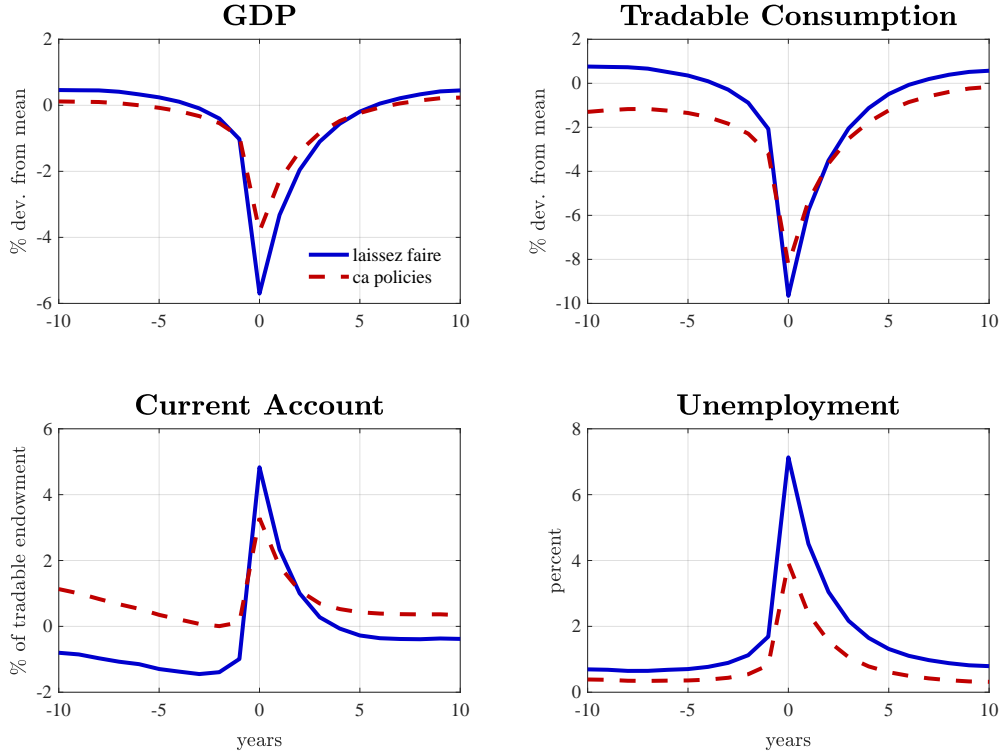
Figure 8: Liquidity trap events: macroeconomic indicators. Solid (dashed) lines refer to economies under laissez faire (current account policies). GDP is defined as $GDP_{i,t} = Y_{i,t}^T + p^N Y_{i,t}^N$, where p^N denotes the unconditional mean of $P_{i,t}^N / P_{i,t}^T$ in the laissez-faire steady state.

to which households respond by accumulating debt in order to sustain tradable consumption. This explains the current account deficits characterizing the run up to the unemployment crisis. Debt accumulation, however, puts the economy at risk of a large drop in tradable consumption in the event of a tightening in the borrowing limit. This is exactly what happens in period 0, when a negative financial shock generates a current account reversal and a large drop in consumption of tradable goods. As tradable consumption falls also aggregate demand for non-tradables drops. Constrained by the zero lower bound, the central bank is unable to react to the decline in domestic demand. The result is a sharp recession lasting several years.[39]

Though negative financial shocks in our model are rare events, the fact that they trigger severe and persistent recessions imply that their impact on unemployment and output is significant. Indeed, in the laissez-faire equilibrium average unemployment is 1.26%.[40] Thus, the combination of financial frictions and of the zero lower bound constraint on monetary policy implies that under laissez faire the world economy operates substantially below potential.

Summing up, the model is able to generate liquidity trap events characterized by severe and persistent rises in unemployment. Crucially, large recessions are triggered by negative financial shocks, and they are more likely to happen in high-debt countries. It is this feature of the model,

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[39]Interestingly, the 6% peak drop in GDP during our typical crisis event is quantitatively in line with the Romer and Romer (2017) empirical estimates of the output response to financial crises in advanced economies.

[40]Since we are focusing on a stationary equilibrium, here average unemployment refers both to the cross-sectional average, that is $1 - \int_0^1 L_{i,t} di$, as well as to the unconditional expected value for a given country.
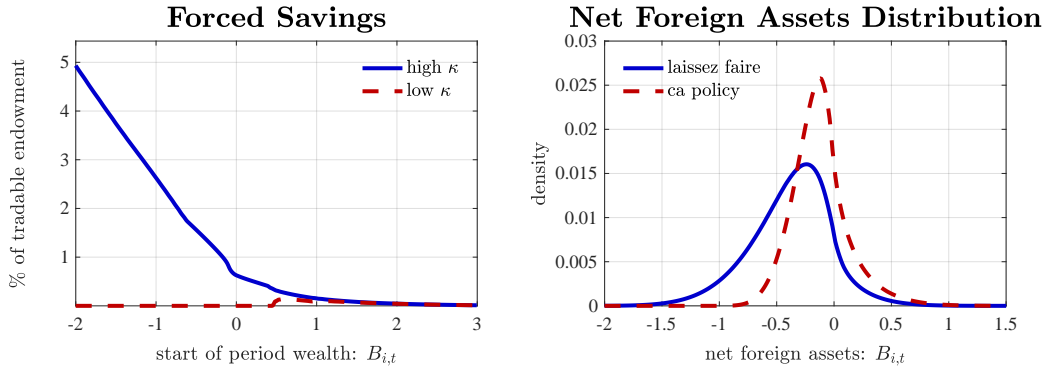
Figure 9: Forced savings and stationary net foreign asset distribution in a small open economy. Right panel: solid (dashed) lines refer to economies under laissez faire (current account policies).

as we will see in the next section, that creates space for current account policies.

5.4 Current account policies: a small open economy perspective

We now turn to government interventions on the international credit markets. As an intermediate step, it is useful to start by taking a partial equilibrium perspective, i.e. by abstracting from the impact of current account policies on the world interest rate. Hence, in this section we consider a single small open economy that implements the optimal current account policy, while the rest of the world sticks to laissez faire.[41]

The dashed lines in Figure 8 show how public interventions on the current account affect the behavior of a country during the liquidity trap events described in the previous section.[42] The key result is that the government intervenes in the run up to the crisis by reducing households' debt accumulation and improving the country's current account. Limiting debt accumulation, the reason is, reduces the exposure of the economy to negative financial shocks. As a result, both the current account reversal and the rise in unemployment occurring in period 0, when access to credit gets tight, are substantially milder under the optimal current account policy compared to laissez faire.

As in the baseline model, the government intervenes on the current account due to the presence of aggregate demand externalities. Private agents, in fact, do not internalize the impact of their borrowing decisions on aggregate demand and employment. It is then natural to think that a government will intervene more aggressively to improve the current account, when conditions are such that a negative financial shock will trigger a sharp rise in unemployment. This is precisely the result illustrated by Figure 9, which shows that the "forced savings" induced by current account

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[41]In Appendix E we provide a detailed description of the national planning problem that we solve to derive the optimal current account policy in the extended model.

[42]To construct this figure, for each liquidity trap event identified under laissez faire we collected the value of net foreign assets in period $t-10$, where period t corresponds to the unemployment peak during the event, as well as the path for the shocks in periods $t-10$ to $t+10$. We then, for each event, fed the corresponding sequence of shocks and initial value for the net foreign assets to the decision rules derived under current account policy. Finally, we took averages of our variables of interest across all the events.

interventions are larger in high-debt countries experiencing lax access to credit.[43]

Quantitatively, public interventions on the current account have a sizable impact on average savings. To illustrate this point, the right panel of Figure 9 compares the stationary net foreign asset distribution of a small open economy operating under laissez faire (solid line), against the one of a country with current account policies (dashed line). The implementation of current account policies induces a rightward shift of the net foreign asset distribution, corresponding to an increase in average savings. The counterpart of this rise in savings is a reduction in unemployment. In fact, the implementation of current account policies by a single country would reduce its average unemployment to 0.5%, down from the 1.26% average unemployment characterizing laissez-faire economies.

Of course, in our model it is perfectly possible for a single country to reduce its average unemployment by means of current account policies. In fact, since we are focusing on small open economies, a change in saving behavior by a single country will not affect the world interest rate. As we show next, matters are completely different when current account policies are adopted on a global scale.

5.5   Revisiting the paradox of global thrift

We have seen that, as in the baseline model, governments have a strong incentive to manipulate their country's current account when the zero lower bound is expected to bind in the future. It is then interesting to consider what happens when current account policies are implemented on a global scale. It turns out that, under our benchmark parametrization, the outcome is a large drop in the world interest rate, which ends up exacerbating the output and welfare losses due to the zero lower bound. This result shows that the logic of the paradox of global thrift goes beyond the simple baseline model presented in Section 2.

Throughout this section we run the following experiment. Imagine that the world starts from the laissez-faire steady state. In period 0 all the countries in the world experience a previously unexpected change in the policy regime, so that governments start implementing the self-oriented optimal current account policy. We are interested in tracing the impact of this policy change on output and welfare.

Before moving on, a few words on multiplicity of equilibria under current account policies are in order. The logic of Proposition 4 applies also to the extended model, and thus the possibility that under some parametrizations multiple equilibria under current account policies exist cannot be discarded. That said, in all the numerical simulations that follow we could not find evidence of multiple equilibria. We thus leave an analysis of equilibrium multiplicity in the extended model for future research.

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[43]Formally, forced savings are defined as $C_{i,t}^T - \tilde{C}_{i,t}^T$, where $\tilde{C}_{i,t}^T$ is the notional consumption that would be chosen by households absent government intervention. In the figure, $Y_{i,t}^T$ is kept equal to its mean value.
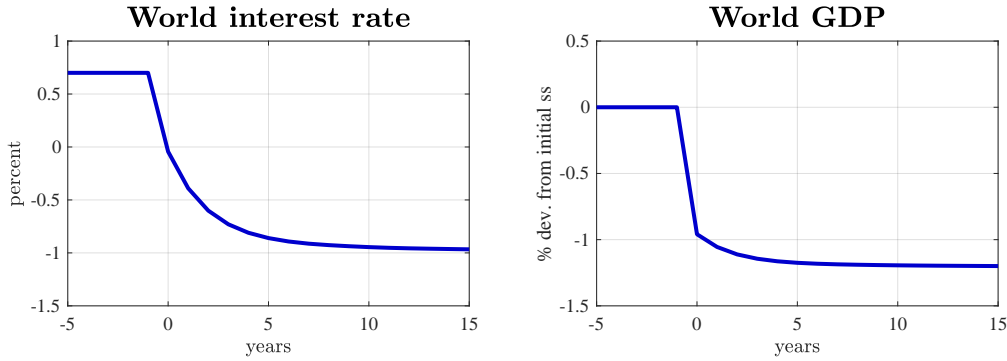
Figure 10: Transition toward steady state with current account policies. World GDP is defined as $\int_0^1 GDP_{i,t}di = \int_0^1 Y_{i,t}^T + p^N Y_{i,t}^N di$, where p^N denotes the unconditional mean of $P_{i,t}^N/P_{i,t}^T$ in the laissez-faire steady state.

5.5.1 Output response to current account policies

Figure 10 plots the path of the world interest rate and world GDP during the transition toward the steady state with current account policies. The change in policy regime induces a gradual drop in the world interest rate. Intuitively, public interventions on the current account increase the aggregate demand for bonds by our model economies. Given the fixed bond supply from the rest of the world the result is a large drop in the world rate, which falls by 170 basis points compared to its value under laissez-faire. The drop in the world interest rate, in turn, exacerbates the zero lower bound constraint on monetary policy and leads to a fall in world output. Indeed, world GDP in the steady state with public interventions on the current account is 1.2% lower than in the laissez-faire equilibrium.[44]

The first row of Table 2 shows the drop in the present value of expected output caused by the global implementation of current account policies, as a percent of expected output in the laissez-faire steady state.[45] On average, the cumulative output loss caused by current account interventions is equal to 1.22% of output in the laissez faire steady state. Moreover, the expected output losses are higher in countries starting the transition with a high stock of debt and tight access to credit. As it is intuitive, the countries that suffer the largest drops in expected output upon implementation of current account policies are those that start the transition inside a liquidity trap.

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[44]The differences in terms of unemployment are even larger. In fact, steady state aggregate unemployment when governments' intervene on the current account is 2.9%, compared to the 1.3% aggregate unemployment in the laissez-faire steady state.

[45]Formally, for any country i we computed the expected cumulative output loss τ_i^y caused by current account policies as

$$E_0\left[\beta^t\sum_{t=0}^{\infty}(1-\tau_i^y)GDP_{i,t}^{lf}\right] = E_0\left[\sum_{t=0}^{\infty}\beta^t GDP_{i,t}^{tr}\right],$$

where $GDP_{i,t}^{lf}$ denotes GDP in the laissez-faire steady state, while $GDP_{i,t}^{tr}$ refers to the path of GDP during the transition toward the steady state with current account policies. GDP is defined as $GDP_{i,t} = Y_{i,t}^T + p^N Y_{i,t}^N$, where p^N denotes the unconditional mean of $P_{i,t}^N/P_{i,t}^T$ in the laissez-faire steady state.

Table 2. Impact of current account policies.

	Average	Net foreign assets ($B_{i,0}$, perc.)				Financial shock ($\kappa_{i,0}$)	
		5th	25th	50th	75th	κ_l	κ_h
Output losses	1.22	1.32	1.24	1.20	1.19	1.24	1.21
Welfare losses	0.087	0.083	0.082	0.085	0.090	0.101	0.078
Welfare losses (NT)	0.308	0.357	0.319	0.301	0.293	0.315	0.304

Notes: All numbers are in percent.

5.5.2 Welfare response to current account policies

We now turn to the impact that current account policies, and the associated drop in the world interest rate, have on welfare. As we discussed in the context of our baseline model, a lower world rate exacerbates the inefficiencies due to the zero lower bound and lead to an inefficiently low production of non-tradable goods. This effect is at the heart of the paradox of global thrift. In the extended model, however, there are two additional effects to consider. First, given that we have moved away from the zero liquidity limit, in the extended model a drop in the world rate redistributes wealth from creditor to debtor countries. Second, since the countries that form our economy are net debtors with respect to the rest of the world, a lower world interest rate redistributes wealth from rest-of-the-world countries toward our model economies. In what follows, we start by discussing how current account policies affect total welfare. We then isolate the channel that is directly connected with the paradox of global thrift by focusing on the non-tradable sector.

The second row of Table 2 illustrates the impact of current account policies on total welfare, by reporting the proportional increase in consumption for all possible future histories that agents living in the laissez-faire equilibrium must receive, in order to be indifferent between the status quo or switching to the equilibrium with current account interventions.[46] These calculations explicitly consider the welfare effect of the whole transitional dynamics toward the steady state with current account policies. The table reports the results in terms of welfare losses, so a positive entry means that the implementation of current account policies lowers welfare compared to the laissez-faire equilibrium.

On average households experience a drop in welfare from governments' interventions on the current account. In fact, on average households are willing to give up permanently 0.087% of their consumption in the laissez-faire equilibrium to prevent the government from implementing the current account policies.[47] While this is not a particularly large number, recall that we are

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[46]More formally, for any country i we computed the welfare loss τ_i^w as

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t U \left((1 - \tau_i^w) C_{i,t}^{lf}, L_{i,t}^{lf} \right) \right] = E_0 \left[\sum_{t=0}^{\infty} \beta^t U \left(C_{i,t}^{tr}, L_{i,t}^{tr} \right) \right],$$

where superscripts lf denote the value of the corresponding variable in the laissez faire steady state, while tr refers to the transition toward the steady state with current account interventions.

[47]As we discuss in Appendix G, our model is likely to underestimate the welfare losses due to unemployment because it assumes that voluntary and involuntary leisure are perfect substitutes. There we show that reducing the Frisch elasticity of labor supply, which corresponds to an increase in the disutility from involuntary unemployment, from our benchmark value of 0.45 to 0.35 increases the welfare losses associated with current account policies by one order of magnitude.

evaluating the welfare impact of programs that governments implement in order to increase citizens' welfare. It is thus striking that these policies end up *lowering* welfare instead.

Interestingly, the welfare losses are evenly spread across debtor and creditor countries. This is the result of two opposing effects. On the one hand, high-debt countries experience larger output losses upon the implementation of current account policies. This effect points toward higher welfare losses in high debt countries. However, high-debt countries also experience a reduction in the cost of servicing their debt following the drop in the world rate. This effect points toward lower welfare losses in high-debt countries. The fact that the welfare losses are evenly distributed across the initial net foreign asset distribution means that these two effects essentially cancel out. Turning to the financial shock, the welfare losses tend to be higher in countries starting the transition during a period of tight access to credit. This is unsurprising, because these are the countries in which the output losses caused by the drop in the world rate are larger.

The third row of Table 2 illustrates the contribution of the non-tradable sector to the welfare losses. To this end, we computed a measure of welfare losses that takes into account only changes in non-tradable consumption and labor effort, thus neglecting the impact of changes in tradable consumption on welfare.[48] This statistic isolates the welfare costs directly linked to the paradox of global thrift, i.e. to the fact that the global implementation of current account policies exacerbates the inefficiencies due to the zero lower bound. In particular, this measure abstracts from the welfare gains driven by the transfer of wealth from the rest of the world to our model economies caused by the drop in the world interest rate.

The table shows that current account interventions substantially exacerbate the inefficiencies due to the zero lower bound. In fact, once we abstract from the wealth effect originating from changes in the world interest rate, on average households are willing to give up permanently 0.308% of their non-tradable consumption in the laissez-faire equilibrium to prevent the government from implementing the current account policies. Moreover, this welfare measure shows that high-debt countries are the ones who suffer the most from the inefficient drop in production caused by the global implementation of current account policies. Indeed, these are the countries in which monetary policy is most constrained by the zero lower bound.

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[48]Here we exploit the fact that under our parametrization the value function is separable in the consumption of tradable and non-tradable goods. To see this point, consider that throughout our numerical simulations we assumed $\sigma = 1/\xi$. Under this assumption it is easy to see that

$$U\left(C_{i,t}, L_{i,t}\right) = \frac{\left(\omega C_{i,t}^T\right)^{1-\sigma} - 1}{1-\sigma} + \frac{\left((1-\omega)C_{i,t}^N\right)^{1-\sigma} - 1}{1-\sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1+\eta}.$$

Now define

$$U^N\left(C_{i,t}^N, L_{i,t}\right) \equiv \frac{\left((1-\omega)C_{i,t}^N\right)^{1-\sigma} - 1}{1-\sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1+\eta}.$$

We computed the welfare losses pertaining to the non-tradable sector τ_i^{wN} as

$$E_0\left[\sum_{t=0}^{\infty} \beta^t U^N\left((1-\tau_i^{wN})C_{i,t}^{Nlf}, L_{i,t}^{lf}\right)\right] = E_0\left[\sum_{t=0}^{\infty} \beta^t U^N\left(C_{i,t}^{Ntr}, L_{i,t}^{tr}\right)\right],$$

where superscripts lf denote the value of the corresponding variable in the laissez faire steady state, while tr refers to the transition toward the steady state with current account interventions.

Summing up, the results from the extended model largely confirm the analytic results that we derived using the simplified framework of Section 2. Current account policies generate a large increase in global savings, giving rise to a sharp drop in the world interest rate. In turn, the lower world rate exacerbates the distortions due to the zero lower bound and leads to a drop in world output. The output drop is larger in countries with a high stock of debt and tight access to credit. Moreover, though governments design current account policies to increase their citizens' welfare, once implemented on a global scale these policy interventions can be welfare-reducing. Because our model is highly stylized, we interpret the quantitative results as being only suggestive. Still, the model points toward the possibility of significant output and welfare losses associated with the paradox of global thrift.[49]

6 Conclusion

In this paper we have shown that during a global liquidity traps governments have an incentive to complement monetary policy with prudential financial and fiscal policies. These policy interventions increase national savings and improve the current account in good times, in order to sustain aggregate demand and employment in the event of a future liquidity trap. The key insight of the paper is that, however, prudential policies might backfire if implemented on a global scale. The reason is that prudential policies increase the global supply of savings and depress global demand. In turn, the drop in global demand exacerbates the output and welfare losses due to the zero lower bound constraint on monetary policy. This effect, which we refer to as the *paradox of global thrift*, might be so strong so that both global output and welfare end up being reduced by the implementation of well-intended prudential policies.

These results suggest that during global liquidity traps international cooperation is needed in order to exploit the stabilization properties of prudential policies. Thus, a natural next step in this research program is to evaluate the macroeconomic impact of different forms of international cooperation. Ideally, one would want to derive the optimal cooperative policy. While this task is feasible in the stylized model of Section 2, matters become much more complicated once the more realistic framework described in Section 5 is considered. For this reason, we have left the characterization of the optimal cooperative policy to future research. Alternatively, one could study simpler forms of international cooperation. For instance, in his 1941 plan Keynes proposed to discourage the emergence of excessively large current account surpluses by imposing simple taxes on capital outflows. We believe that our framework represents a useful starting point for future research aiming at evaluating this and other forms of international cooperation during global liquidity traps.

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[49]In Appendix G we provide a sensitivity analysis and show how our quantitative results are affected by changes in some key model parameters. In particular, we consider changes in the disutility from involuntary unemployment and in inflation expectations. We also consider a version of the model in which the supply of bonds from the rest of the world responds to variations in the world interest rate.

Appendix

A Additional lemmas

Lemma 2 *Suppose that the market for non-tradable goods clears competitively, so that the (AD) and (MP) equations hold. Then there cannot be a stationary equilibrium with $Y_{i,t}^N < 1$ for all t. Moreover if $C_h^T \geq C_l^T$ then $Y_h^N = 1$.*

Proof. The proof is by contradiction. Suppose that $Y_{i,t}^N < 1$ for all t. (MP) then implies $R_{i,t}^n = 1$ for all t. In a stationary equilibrium the AD equation in the low and high state can then be written as

$$Y_h^N = R\bar{\pi} \frac{C_h^T}{C_l^T} Y_l^N \tag{A.1}$$

$$Y_l^N = R\bar{\pi} \frac{C_l^T}{C_h^T} Y_h^N. \tag{A.2}$$

Combining these equations gives $1 = (R\bar{\pi})^2$.[50] This contradicts Assumption (2), which states $R\bar{\pi} > 1$. Hence, in a stationary equilibrium it must be that $\max\{Y_h^N, Y_l^N\} = 1$.

We now prove that if $C_h^T \geq C_l^T$ then $Y_h^N = 1$. Suppose that this is not the case and $Y_h^N < 1$. Then (MP) implies $R_h^N = 1$ and $Y_l^N = 1$. We can then write the (AD) equation in the high state as

$$Y_h^N = R\bar{\pi} \frac{C_h^T}{C_l^T}. \tag{A.3}$$

Assumption (2) and $C_h^T \geq C_l^T$ imply that the right-hand side is larger than one. Hence, $Y_h^N > 1$. We have found a contradiction, and so $C_h^T \geq C_l^T$ implies $Y_h^N = 1$. ∎

Lemma 3 *In a stationary solution to the national planning problem $Y_h^N = 1$, $\bar{v}_h = 0$ and $\bar{\mu}_l > 0$.*

Proof. We start by showing that $Y_h^N = 1$, that is that in a stationary solution to the planning problem the economy operates at full employment in the high state. Suppose, to reach a contradiction, that $Y_h^N < 1$. Applying Lemma 2, we can set $Y_l^N = 1$. Thus, (24) in the high state implies $R\bar{\pi} C_h^T / C_l^T < 1$. Since by Assumption (2) $1 < R\bar{\pi}$, then $C_l^T > C_h^T$. Since $Y_h^T > Y_l^T$ and $B_l \geq -\kappa \approx 0$, this is possible only if $B_h > 0$ and so if $\bar{\mu}_h = 0$. Combining (26) and (31) in the high state and rearranging then gives[51]

$$\frac{C_l^T}{C_h^T} = \beta R(1 - \bar{v}_l) - (1-\omega)\frac{\partial C_l^T / \partial B_h}{C_l^T}. \tag{A.4}$$

Recall that we are focusing on equilibria in which $\partial C_l^T / \partial B_h \geq 0$. Then, since $\beta R < 1$ and $\bar{v}_l \geq 0$, the right-hand side of this equation is always smaller than 1, implying that $C_l^T < C_h^T$. We have thus reached a contradiction and proved that $Y_h^N = 1$.

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[50]We do not consider equilibria featuring $Y_h^N = Y_l^N = 0$.

[51]We have also used the facts that since $Y_h^N < 1$ then $\bar{v}_h = 0$ and since $Y_l^N = 1$ then $\partial Y_l^N / \partial B_h = 0$.

We turn to prove that $\bar{v}_h = 0$, that is that the zero lower bound does not bind in the high state. To reach a contradiction, assume instead that $\bar{v}_h > 0$. Since we proved that $Y_h^N = 1$, we can use (24) to write

$$1 = R\bar{\pi}\frac{C_h^T}{C_l^T}Y_l^N. \tag{A.5}$$

First, suppose that $\bar{v}_l > 0$. Equation (24) implies $Y_l^N = R\bar{\pi}C_l^T/C_l^T$. Using these two conditions equation (A.5) reduces to $1 = (R\bar{\pi})^2$, that contradicts our assumption $R\bar{\pi} > 1$. Therefore, it is not possible that $\bar{v}_l > 0$ and $\bar{v}_h > 0$.

Let us now turn to analyze the case $\bar{v}_l = 0$ and $\bar{v}_h > 0$. Since in this case $Y_l^N = 1$, (24) implies $1 \leq R\bar{\pi}C_l^T/C_h^T$. Moreover, by using (A.5) and $Y_l^N = 1$, we get $C_l^T/C_h^T = R\bar{\pi}$. Jointly, these two conditions imply $C_h^T \leq C_l^T$. Since $Y_h^T > Y_l^T$ and $B_l \geq -\kappa \approx 0$, this is possible only if $B_h > 0$ and so if $\bar{\mu}_h = 0$. Note that, since $\bar{v}_l = \bar{\mu}_h = 0$ and $Y_h^N = 1$, we can write equation (31) in the high state as

$$\frac{\omega + \bar{v}_h}{C_h^T} = \beta R\frac{\omega}{C_l^T} - \bar{v}_h\frac{\partial C_l^T/\partial B_h}{C_l^T}. \tag{A.6}$$

Since $\beta R < 1$ and $\partial C_l^T/\partial B_h \geq 0$, this expression implies $C_l^T < C_h^T$. We have reached a contradiction. We have thus reached a contradiction and proved that $\bar{v}_h = 0$.

We are left to prove that $\bar{\mu}_l > 0$, that is that in a stationary solution to the planning problem the borrowing constraint binds in the low state. Suppose instead that $\bar{\mu}_l = 0$. Thus, considering that $Y_h^N = 1$ and $\bar{v}_h = 0$, the Euler equation (31) in the low state implies

$$\frac{\omega + \bar{v}_l Y_l^N}{C_l^T} = \beta R\frac{\omega}{C_h^T} - \bar{v}_h\frac{\partial C_l^T/\partial B_h}{C_l^T}. \tag{A.7}$$

Since $\beta R < 1$ and $\partial C_l^T/\partial B_h \geq 0$, the following condition needs to hold $C_h^T < C_l^T$. Since $Y_h^T > Y_l^T$ and $B_l \geq -\kappa \approx 0$, this is possible only if $B_h > 0$ and so if $\bar{\mu}_h = 0$. Then the Euler equation (31) in the high state is

$$\frac{\omega}{C_h^T} = \beta R\frac{\omega + \bar{v}_l Y_l^N}{C_l^T}. \tag{A.8}$$

By combining (A.7) and (A.8), and using $\partial C_l^T/\partial B_h \geq 0$, we obtain $\beta R \geq 1$. This contradicts the assumption $\beta R < 1$. Thus, it must be that $\bar{\mu}_l > 0$. ∎

B   Proofs

B.1   Proof of Proposition 1

Proposition 1 *Small open economy under laissez faire. There exists a threshold R^*, such that if $R \geq R^*$ then $Y_h^N = Y_l^N = 1$, otherwise $Y_h^N = 1$ and $Y_l^N = R\bar{\pi}\max\left(\beta R, Y_l^T/Y_h^T\right) < 1$. R^* solves $R^*\bar{\pi}\max\left(\beta R^*, Y_l^T/Y_h^T\right) = 1$.*

Proof. Since the competitive equilibrium is stationary and satisfies $C_h^T > C_l^T$ Lemma 2 applies.

Hence, $Y_h^N = 1$. Using these conditions the (AD) equation in the low state can be written as

$$Y_l^N = \frac{R\bar{\pi}}{R_l^n} \frac{C_l^T}{C_h^T} = \frac{R\bar{\pi}}{R_l^n} \max\left\{\beta R, \frac{Y_l^T}{Y_h^T}\right\},$$

where the second equality makes use of (16), (17) and (18). Define R^* as the solution to $1 = R^*\bar{\pi}\max\left\{\beta R^*, Y_l^T/Y_h^T\right\}$. Combining the expression above with the (MP) equation, gives that if $R \geq R^*$, then $Y_l^N = 1$ and $R_l^n \geq 1$, otherwise $R_l^n = 1$ and $Y_l^N = R\bar{\pi}\max\left(\beta R, Y_l^T/Y_h^T\right) < 1$. ∎

B.2 Proof of Proposition 2

Proposition 2 *National planner allocation. Consider stationary solutions to the national planning problem. Define $R^{**} = \omega Y_l^T/(\beta Y_h^T)$ and $\tilde{R} \equiv (\omega/(\bar{\pi}\beta))^{1/2}$. The planning allocation is such that $Y_h^N = 1$, $Y_l^N = Y_l^{Np}$, $B_h = B_h^p$ and $B_l = 0$, where Y_l^{Np} and B_h^p are defined as*

$$
\begin{cases}
B_h^p = 0, Y_l^{Np} = R\bar{\pi}Y_l^T/Y_h^T < 1 & \text{if} \qquad R < R^{**} \\
B_h^p = \frac{\beta}{\omega+\beta}\left(Y_h^T - \frac{\omega Y_l^T}{\beta R}\right), Y_l^{Np} = R^2\bar{\pi}\beta/\omega < 1 & \text{if } R^{**} \leq R < \tilde{R} \\
B_h^p = \frac{Y_h^T - R\bar{\pi}Y_l^T}{1+R^2\bar{\pi}}, Y_l^{Np} = 1 & \text{if } \tilde{R} \quad \leq R < R^* \\
B_h^p = \max\left\{\frac{\beta}{1+\beta}\left(Y_h^T - \frac{Y_l^T}{\beta R}\right), 0\right\}, Y_l^{Np} = 1 & \text{if } R^* \quad \leq R.
\end{cases}
\tag{B.1}
$$

Moreover, $\bar{\mu}_h > 0$ if $R < R^{**}$ or $R^* \leq R < Y_l^T/(Y_h^T\beta)$, otherwise $\bar{\mu}_h = 0$.

Proof. In this proof we solve for the small open economy equilibrium with current account policy as a function of R. Throughout the proof, we will denote with a ¯ the value of the corresponding variable in the equilibrium under non-cooperative financial policy, while a ˆ will denote the value of a variable under laissez faire.

We start by considering the case $R \geq R^*$. Our goal is to show that in this case the planning allocation coincide with the laissez faire one. Let us start by guessing that $\bar{v}_{i,t} = 0$ for all t. In this case, the planner Euler equation (31) coincides with the households' Euler equation (4) under laissez faire. It follows that the path of tradable consumption in the two allocations coincide for all t. Since $R \geq R^*$, following the steps outlined in the proof to Proposition 1, one can prove that $C_{i,t}^N = 1$ for all t, just as in the laissez faire equilibrium. This implies that it is possible to set $\bar{v}_{i,t} > 0$ for all t. Hence, we can set $\bar{v}_{i,t} = 0$ for all t without violating the optimality condition (26). This verifies our initial guess $\bar{v}_{i,t} = 0$ for all t, and it proves that if $R \geq R^*$ the planning allocation coincide with the laissez faire one.

We now turn to the case $R < R^*$. Lemma 3 implies that in the planning allocation $C_h^N = 1$, $\bar{v}_h = 0$ and $\bar{\mu}_l > 0$. The next step of the proof establishes that if $R < R^*$ then $\bar{v}_l > 0$, that is the zero lower bound binds in the low state. Suppose the contrary, meaning that $R < R^*$ and $\bar{v}_l = 0$. Then (31) is identical to (4) and the path of tradable consumption in the planning allocation coincide with the one under laissez faire. But, following the steps outlined in Proposition 1, one can show that then the planning allocation $C_l^N < 1$. Therefore, condition (26) implies $\bar{v}_l > 0$,

contradicting our initial assumption. This proves that if $R < R^*$ then $\bar{v}_l > 0$. For future reference, note that, as a consequence, when $R < R^*$ the optimality condition (24) in the low state implies

$$Y_l^N = R\bar{\pi}C_l^T/C_h^T. \tag{B.2}$$

We now solve for Y_l^N and B_h as a function of $R < R^*$. We start by deriving conditions under which $Y_l^N = 1$. Note that if $R < R^*$ there cannot be an equilibrium with $Y_l^N = 1$ and $\bar{\mu}_h > 0$.[52] Setting $\bar{\mu}_h = 0$, we can write (31) in the high state as

$$\frac{\omega}{C_h^T} = \frac{\beta R}{C_l^T}(\omega + \bar{v}_l Y_l^N) = \frac{\beta R}{C_l^T}(1 - \bar{\nu}_l), \tag{B.3}$$

where the second equality makes use of $Y_l^N = 1$ and (26). Moreover, equation (B.2) implies

$$1 = R\bar{\pi}C_l^T/C_h^T. \tag{B.4}$$

Combining (B.3) and (B.4) gives
$$\omega = R^2\bar{\pi}\beta(1 - \bar{\nu}_l). \tag{B.5}$$

Since we are free to set $\bar{\nu}_l$ to any non-negative number, the expression above implies that in order for $Y_l^N = 1$ to be a solution it must be that $R \geq (\omega/(\bar{\pi}\beta))^{1/2} \equiv \tilde{R}$. To solve for B_h we can use (17), (18) and (B.4) to write

$$B_h = \frac{Y_h^T - R\bar{\pi}Y_l^T}{1 + R^2\bar{\pi}}. \tag{B.6}$$

It is straightforward to prove that $R < R^*$ implies $Y_h^T > R\bar{\pi}Y_l^T$, and hence $B_h > -\kappa \approx 0$.[53] We can then conclude that for $\tilde{R} \leq R < R^*$ the planning allocation features $Y_l^N = 1$, while B_h is given by (B.6).

Finally we characterize the equilibria where $Y_l^N < 1$. We set $\bar{\nu}_l = 0$ and we use (26) to obtain $\bar{v}_l = (1 - \omega)Y_l^N$. Suppose that the equilibrium is such that $\bar{\mu}_h = 0$. Plugging this condition in the Euler equation for the high state gives

$$\frac{C_l^T}{C_h^T} = \frac{\beta R}{\omega}. \tag{B.7}$$

By combining the expression above with (B.2) we can write

$$Y_l^N = \bar{\pi}\frac{\beta R^2}{\omega}. \tag{B.8}$$

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[52]To see this point, assume that $\bar{\mu}_h > 0$ and $Y_l^N = 1$. Since by Lemma 3 also $\bar{\mu}_l > 0$ then $C_h^T = Y_h^T$ and $C_l^T = Y_l^T$. Hence, in order for equation (B.2) to hold it must be that $R\bar{\pi}Y_l^T/Y_h^T = 1$. But this is inconsistent with $R < R^*$. We have found a contradiction. Thus, if $R < R^*$ and $Y_l^N = 1$, it must be that $\bar{\mu}_h = 0$.

[53]Since $R < R^*$, it is sufficient to prove that $\bar{\pi}R^* \leq Y_h^T/Y_l^T$. Consider that R^* solves $1 = R^*\bar{\pi}\max\{\beta R^*, Y_l^T/Y_h^T\}$. Suppose that $\beta R^* > Y_l^T/Y_h^T$, meaning $R^* = (\beta\bar{\pi})^{-1/2}$. Then, $(\beta/\bar{\pi})^{1/2} = \frac{1}{\bar{\pi}R^*} > Y_l^T/Y_h^T$. Assume instead $\beta R^* \leq Y_l^T/Y_h^T$, it follows that $\bar{\pi}R^* = Y_h^T/Y_l^T$. Thus, since $R^* \leq \frac{Y_h^T}{Y_l^T\bar{\pi}}$, all $R < R^* < \frac{Y_h^T}{Y_l^T\bar{\pi}}$.

This is a solution if $B_h \geq -\kappa \approx 0$. To solve for B_h we use (17), (18) and (B.7) to write

$$B_h = \frac{\beta}{\omega + \beta} \left(Y_h^T - \frac{\omega Y_l^T}{\beta R} \right). \tag{B.9}$$

Hence in the interval $\omega Y_l^T / (\beta Y_h^T) \equiv R^{**} < R < \min\left(R^*, \tilde{R}\right)$, $Y_l^N = \bar{\pi}\beta R^2/\omega$, while B_h is given by (B.9) . Instead if $R \leq R^{**}$ then $\bar{\mu}_h > 0$ and the planning allocation coincide with the laissez faire one. $\blacksquare$

B.3   Proof of Proposition 3

Proposition 3 *Global equilibrium with current account policies.* Suppose that $R^{lf} < R^*$. *Then $R^p < R^{lf}$, where R^p is the world interest rate that clears the global credit markets when governments implement current account policies. Moreover, world output and welfare are lower in the equilibrium with current account policies compared to the laissez-faire one.*

Proof. Define the function $\mathcal{B}_h^p(R)$, as the planner's demand for bonds in the high state characterized in Proposition (32). In a global equilibrium with current account policies it must be that $\mathcal{B}_h^p(R^p) = 0$ and $\bar{\mu}_h = 0$. We start by observing that $R^p \geq R^{**}$. This follows from Proposition 2 which states that if $R < R^{**}$ then $\bar{\mu}_h > 0$.

We now show that if $R^{lf} < R^*$ then there exist a unique $R^p < R^{lf}$ Clearly $R^p \geq R^*$ can't be a solution. In fact, for $R \geq R^*$ the demand for bonds by national planners coincide with the one under laissez faire, and so $\mathcal{B}_h^p(R) > 0$. Moreover, $\tilde{R} \leq R^{nc} < R^*$ can't be a solution either. Consider that $\mathcal{B}_h^p(R^*) > 0$, and that over the range $\tilde{R} \leq R^p < R^*$ we have $\mathcal{B}_h^{p'}(R) > 0$. This implies that there can't be an $\tilde{R} \leq R < R^*$ such that $\mathcal{B}_h^p(R) = 0$. It must then be that $R^{**} \leq R^p < \tilde{R}$. We then have $R^p = \omega Y_l^T / (\beta Y_h^T) = R^{**}$. Moreover since $\omega < 1$, we obtain $R^p < R^{lf}$.

We now show that Y_l^N and welfare are lower with current account interventions compared to laissez faire. Independently of whether governments intervene on the credit markets $C_l^T = Y_l^T, C_h^T = Y_h^T$ and $Y_h^N = 1$. Moreover, following Proposition (32), we can write non-tradable output in the low state as

$$Y_l^N = \min\left(R\bar{\pi}Y_l^T / Y_h^T, 1\right).$$

Since $R^p < R^{lf}$ it immediately follows that Y_l^N is lower in the equilibrium with current account policy than in the laissez-faire equilibrium. Since the impact on welfare of credit market interventions is fully determined by Y_l^N, it follows that also welfare is lower in the equilibrium with current account policy than in the laissez-faire equilibrium $\blacksquare$

B.4   Proof of Proposition 4

Proposition 4 *Multiple equilibria with current account policy.* Suppose that $R^{lf} \geq R^*$. *Then $R^p = R^{lf}$ is an equilibrium under the non-cooperative current account policy. This equilibrium is isomorphic to the laissez-faire one. However, if $R^{**} < R^*$, there exists at least another*

equilibrium under the non-cooperative current account policy with associated world interest rate $R^{p\prime} < R^*$. This equilibrium features lower output and welfare than the laissez faire one.

Proof. In a global equilibrium it must be that $\mathcal{B}_h^p(R^p) = 0$ and $\hat{\mu}_h = 0$. Notice that $R^p = R^{lf}$ is an equilibrium. This is the case because $R^{lf} \geq R^*$ implies that at the solution the demand for bonds with current account interventions and under laissez faire coincide. If $R^{**} \geq R^*$, this is the unique solution, because the demand for bonds are independent of current account interventions for any value of R. Now assume that $R^{**} < R^*$. Then there exists a second solution $R^{p\prime} = R^{**}$, because $\mathcal{B}_h^p(R^{**}) = 0$. Moreover, since $R^{**} < R^*$ this second solution corresponds to a global liquidity trap. The welfare statement can be proved following the steps in the proof to Proposition 4. ∎

C Microfoundations for the zero lower bound constraint

In this appendix we provide some possible microfoundations for the zero lower bound constraint assumed in the main text. First, let us introduce an asset, called money, that pays a private return equal to zero in nominal terms.[54] Money is issued exclusively by the government, so that the stock of money held by any private agent cannot be negative. Moreover, we assume that the money issued by the domestic government can be held only by domestic agents.

We modify the borrowing limit (3) to

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} + \frac{M_{i,t+1}}{P_{i,t}^T} \geq -\kappa_{i,t},$$

where $M_{i,t+1}$ is the stock of money held by the representative household in country i at the end of period t. The optimality condition for money holdings can be written as

$$\frac{1}{C_{i,t}^T} = \frac{P_{i,t}^T}{P_{i,t+1}^T} \frac{\beta}{C_{i,t+1}^T} + \mu_{i,t} + \mu_{i,t}^M,$$

where $\mu_{i,t}^M \geq 0$ is the Lagrange multiplier on the non-negativity constraint for private money holdings, divided by $P_{i,t}^T$. Combining this equation with (5) gives

$$\left(R_{i,t}^n - 1\right) \frac{\beta}{C_{i,t+1}^T} = \mu_{i,t}^M.$$

Since $\mu_{i,t}^M \geq 0$, this expression implies that $R_{i,t}^n \geq 1$. Moreover, if $R_{i,t}^n > 1$, then agents choose to hold no money. If instead $R_{i,t}^n = 1$, agents are indifferent between holding money and bonds. We resolve this indeterminacy by assuming that the aggregate stock of money is infinitesimally small for any country and period.

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[54]Here we focus on the role of money as a saving vehicle, and abstract from other possible uses. More formally, we place ourselves in the cashless limit, in which the holdings of money for purposes other that saving are infinitesimally small.

D Optimal discretionary monetary policy

We derive the constrained efficient allocation by taking the perspective of a benevolent central bank that operates in a generic country i, and solves its maximization problem in period τ. For given initial net foreign assets $B_{i,\tau}$ and paths $\{Y_{i,t}^T, \kappa_{i,t}, R_t\}_{t \geq \tau}$, the central bank maximizes equation (1) subject to equations (4), (6), (11), (13) and[55]

$$C_{i,t}^N = \min\left(\frac{R_t \pi_{i,t+1} C_{i,t}^T C_{i,t+1}^N}{R_{i,t}^n C_{i,t+1}^T}, 1\right) \tag{D.1}$$

$$C_{i,t}^N \leq 1, \pi_{i,t} \geq \gamma \quad \text{with complementary slackness} \tag{D.2}$$

$$R_{i,t}^n \geq 1, \tag{D.3}$$

for any $t \geq \tau$. Start by considering that from equations (4), (6), (11) and (13) it is possible to solve for the paths $\{C_{i,t}^T, B_{i,t+1}\}_{t \geq \tau}$ independently of monetary policy. Hence, monetary policy can affect utility only through its impact on $\{C_{i,t}^N\}_{t \geq \tau}$. Moreover, notice that $B_{i,t+1}$ represents the only endogenous state variable of the economy.

We now restrict attention to a central bank that operates under discretion, that is by taking future policies as given. Since monetary policy cannot affect the state variables of the economy, it follows that a central bank operating under discretion cannot influence future variables at all. The problem of the central bank can be thus written as

$$\max_{R_{i,\tau}, C_{i,\tau}^N, \pi_{i,\tau}} \log(C_{i,\tau}^N), \tag{D.4}$$

$$C_{i,\tau}^N = \min\left(\nu_{i,\tau}/R_{i,\tau}^n, 1\right) \tag{D.5}$$

$$C_{i,\tau}^N \leq 1, \pi_{i,\tau} \geq \gamma \quad \text{with complementary slackness} \tag{D.6}$$

$$R_{i,\tau}^n \geq 1, \tag{D.7}$$

where $\nu_{i,\tau} \equiv R_\tau \pi_{i,\tau+1} C_{i,\tau}^T C_{i,\tau+1}^N / C_{i,\tau+1}^T$. The central bank takes $\nu_{i,\tau}$ as given because it is a function of present and future variables that monetary policy cannot affect.

The solution to this problem can be expressed as

$$R_{i,\tau}^n \geq 1, C_{i,\tau}^N \leq 1 \quad \text{with complementary slackness.} \tag{D.8}$$

Intuitively, it is optimal for the central bank to lower the policy rate until the economy reaches full employment or the zero lower bound constraint binds. Moreover, it follows from constraint (D.6) that any $\pi_{i,\tau} \geq \gamma$ is consistent with constrained efficiency. In fact, as long as the central bank faces an infinitesimally small cost from deviating from its inflation target $\bar{\pi}$, then the constrained

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[55]Constraint (D.1) is obtained by combining (AD) and (12) with the restriction $Y_{i,t}^N \leq 1$. Constraint (D.2) is obtained by combining (10) with $L_{i,t} = Y_{i,t}^N = C_{i,t}^N$ and $P_{i,t}^N = W_{i,t}$.

efficient allocation features $\pi_{i,\tau} = \bar{\pi}$.[56] This is exactly the policy implied by the rule (MP).

E   Model used in the numerical analysis

This appendix presents a detailed description of the model studied in Section 5.

E.1   Setup and competitive equilibrium

As in the baseline model, we consider a world composed of a continuum of measure one of small open economies indexed by $i \in [0,1]$. Time is discrete and indexed by $t \in \{0,1,...\}$. There is no uncertainty at the world level, but our small open economies are subject to idiosyncratic risk.

Each country is populated by a continuum of measure one of identical infinitely-lived households. The lifetime utility of the representative household in a generic country i is

$$E_0 \left[\sum_{t=0}^{\infty} \beta^t \left(\frac{C_{i,t}^{1-\sigma} - 1}{1 - \sigma} - \chi \frac{L_{i,t}^{1+\eta}}{1 + \eta} \right) \right], \tag{E.1}$$

where $E_t[\cdot]$ is the expectation operator conditional on information available at time t, $0 < \beta < 1$, $\sigma > 0$, $\chi > 0$ and $\eta \geq 0$. $L_{i,t}$ denotes labor effort. Consumption $C_{i,t}$ is defined as

$$C_{i,t} = \left(\omega \left(C_{i,t}^T \right)^{1-\frac{1}{\xi}} + (1 - \omega) \left(C_{i,t}^N \right)^{1-\frac{1}{\xi}} \right)^{\frac{\xi}{\xi-1}}, \tag{E.2}$$

where $0 < \omega < 1$ and $\xi > 0$. $C_{i,t}^T$ and $C_{i,t}^N$ denote consumption of respectively a tradable and a non-tradable good.

Households. Households can trade in one-period real and nominal bonds. Real bonds are denominated in units of the tradable consumption good and pay the gross interest rate R_t. The interest rate on real bonds is common across countries, and R_t can be interpreted as the *world interest rate*. Nominal bonds are denominated in units of the domestic currency and pay the gross nominal interest rate $R_{i,t}^n$. To simplify the analysis, we assume that households cannot purchase foreign currency denominated bonds.

The household budget constraint in terms of the domestic currency is

$$P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N + P_{i,t}^T B_{i,t+1} + B_{i,t+1}^n = W_{i,t} L_{i,t} + P_{i,t}^T Y_{i,t}^T + P_{i,t}^T R_{t-1} B_{i,t} + R_{i,t-1}^n B_{i,t}^n. \tag{E.3}$$

The left-hand side of this expression represents the household's expenditure. $P_{i,t}^T$ and $P_{i,t}^N$ denote respectively the price of a unit of tradable and non-tradable good in terms of country i currency. Hence, $P_{i,t}^T C_{i,t}^T + P_{i,t}^N C_{i,t}^N$ is the total nominal expenditure in consumption. $B_{i,t+1}$ and $B_{i,t+1}^n$ denote respectively the purchase of real and nominal bonds made by the household at time t. If $B_{i,t+1} < 0$ or $B_{i,t+1}^n < 0$ the household is holding a debt.

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[56]Recall that we are assuming $\bar{\pi} > \gamma$.

The right-hand side captures the household's income. $W_{i,t}$ denotes the nominal wage, and hence $W_{i,t}L_{i,t}$ is the household's labor income. Labor is immobile across countries and so wages are country-specific. $Y_{i,t}^T$ is an endowment of tradable goods received by the household. Changes in $Y_{i,t}^T$ can be interpreted as movements in the quantity of tradable goods available in the economy, or as shocks to the country's terms of trade. $P_{i,t}^T R_{t-1} B_{i,t}$ and $R_{i,t-1}^n B_{i,t}^n$ represent the gross returns on investment in bonds made at time $t-1$.

There is a limit to the amount of debt that a household can take. In particular, the end-of-period bond position has to satisfy

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t} + \theta\left(R_{t-1}B_{i,t} + R_{i,t-1}^n \frac{B_{i,t}^n}{P_{i,t}^T}\right), \tag{E.4}$$

where $\kappa_{i,t} \geq 0$ and $\theta \geq 0$. As we discuss in the main text, when $\theta > 0$ this constraint places an upper bound on the growth rate of the households' stock of debt.

Each household chooses its desired amount of hours worked, denoted by $L_{i,t}^s$. However, due to the presence of nominal wage rigidities to be described below, the household might end up working less than its desired amount of hours, i.e.

$$L_{i,t} \leq L_{i,t}^s, \tag{E.5}$$

where $L_{i,t}$ is taken as given by the household.

The household's optimization problem consists in choosing a sequence $\{C_{i,t}^T, C_{i,t}^N, B_{i,t+1}, B_{i,t+1}^n, L_{i,t}^s\}_t$ to maximize lifetime utility ($E.1$), subject to the budget constraint ($E.3$), the borrowing limit ($E.4$) and the constraint on hours worked ($E.5$), taking initial wealth $P_0^T R_{-1} B_{i,0} + R_{i,-1}^n B_{i,0}^n$, a sequence for income $\{W_{i,t}L_{i,t} + P_{i,t}^T Y_{i,t}^T\}_t$, and prices $\{R_t, R_{i,t}^n, P_{i,t}^T, P_{i,t}^N\}_t$ as given. The household's first-order conditions can be written as

$$\frac{\omega C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^T\right)^{\frac{1}{\xi}}} = \beta R_t E_t\left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta\mu_{i,t+1}\right] + \mu_{i,t} \tag{E.6}$$

$$\frac{\omega C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^T\right)^{\frac{1}{\xi}}} = \beta R_{i,t}^n E_t\left[\frac{P_{i,t}^T}{P_{i,t+1}^T}\left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta\mu_{i,t+1}\right)\right] + \mu_{i,t} \tag{E.7}$$

$$B_{i,t+1} + \frac{B_{i,t+1}^n}{P_{i,t}^T} \geq -\kappa_{i,t} + \theta\left(R_{t-1}B_{i,t} + R_{i,t-1}^n \frac{B_{i,t}^n}{P_{i,t}^T}\right) \quad \text{with equality if} \quad \mu_{i,t} > 0 \tag{E.8}$$

$$C_{i,t}^N = \left(\frac{1-\omega}{\omega}\frac{P_{i,t}^T}{P_{i,t}^N}\right)^{\xi} C_{i,t}^T, \tag{E.9}$$

$$L_{i,t}^s = \left(\frac{1-\omega}{\chi} \frac{W_{i,t}}{P_{i,t}^N} \frac{C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^N\right)^{\frac{1}{\xi}}} \right)^{\frac{1}{\eta}}, \tag{E.10}$$

where $\mu_{i,t}$ is the nonnegative Lagrange multiplier associated with the borrowing constraint. Equations ($E.6$) and ($E.7$) are the Euler equations for, respectively, real and nominal bonds. Equation ($E.8$) is the complementary slackness condition associated with the borrowing constraint. Equation ($E.9$) determines the optimal allocation of consumption expenditure between tradable and non-tradable goods. Equation ($E.10$) gives the household's labor supply.

It is useful to combine ($E.6$) and ($E.7$) to obtain a no arbitrage condition between real and nominal bonds

$$R_{i,t}^n = R_t \frac{E_t\left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right]}{E_t\left[\frac{P_{i,t}^T}{P_{i,t+1}^T} \left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right) \right]}. \tag{E.11}$$

We can then use ($E.9$) and ($E.11$) to get the analogue of the baseline model's AD equation

$$C_{i,t}^N = C_{i,t}^T \left(\frac{R_t}{R_{i,t}^n} \frac{E_t\left[\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right]}{E_t\left[\pi_{i,t+1} \left(\frac{C_{i,t+1}^T}{C_{i,t+1}^N} \right)^{\frac{1}{\xi}} \left(\frac{\omega C_{i,t+1}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t+1}^T\right)^{\frac{1}{\xi}}} - \theta \mu_{i,t+1} \right) \right]} \right)^{\xi}. \tag{E.12}$$

where $\pi_{i,t} \equiv P_{i,t}^N / P_{i,t-1}^N$.

Firms and nominal rigidities. Non-traded output $Y_{i,t}^N$ is produced by a large number of competitive firms. Labor is the only factor of production, and the production function is

$$Y_{i,t}^N = L_{i,t}. \tag{E.13}$$

Profits are given by $P_{i,t}^N Y_{i,t}^N - W_{i,t} L_{i,t}$, and the zero profit condition implies that in equilibrium $P_{i,t}^N = W_{i,t}$. Using this condition we can simplify the labor supply equation ($E.10$) to

$$L_{i,t}^s = \left(\frac{1-\omega}{\chi} \frac{C_{i,t}^{\frac{1}{\xi}-\sigma}}{\left(C_{i,t}^N\right)^{\frac{1}{\xi}}} \right)^{\frac{1}{\eta}}. \tag{E.14}$$

Nominal wages are subject to the downward rigidity constraint

$$W_{i,t} \geq \gamma W_{i,t-1},$$

where $\gamma > 0$. Equilibrium on the labor market is captured by the condition

$$L_{i,t} \leq L_{i,t}^s, \quad W_{i,t} \geq \gamma W_{i,t-1} \quad \text{with complementary slackness.} \tag{E.15}$$

This condition implies that unemployment, defined as a downward deviation of hours worked from the household's desired amount, arises only if the constraint on wage adjustment binds.

Monetary policy and inflation. The objective of the central bank is to set $\pi_{i,t} = \bar{\pi}$. As in the baseline model, we focus on the case $\bar{\pi} > \gamma$, so that $\pi_{i,t} = \bar{\pi} \to L_{i,t} = L_{i,t}^s$. The central bank runs monetary policy by setting the nominal interest rate $R_{i,t}^n$, subject to the zero lower bound constraint $R_{i,t}^n \geq 1$. We also, as in the baseline model, restrict attention to the constant-inflation limit $\bar{\pi} \to \gamma$. Hence monetary policy can be described by the rule

$$R_{i,t}^n = \begin{cases} \geq 1 & \text{if } Y_{i,t}^N = L_{i,t}^s \\ = 1 & \text{if } Y_{i,t}^N < L_{i,t}^s, \end{cases} \tag{E.16}$$

where we have used (10) and the equilibrium relationships $W_{i,t} = P_{i,t}^N$ and $L_{i,t} = Y_{i,t}^N$.

Market clearing and definition of competitive equilibrium Since households inside a country are identical, we can interpret equilibrium quantities as either household or country specific. For instance, the end-of-period net foreign asset position of country i is equal to the end-of-period holdings of bonds of the representative household, $NFA_{i,t} = B_{i,t+1} + B_{i,t+1}^n / P_{i,t}^T$. Throughout, we focus on equilibria in which nominal bonds are in zero net supply, so that

$$B_{i,t}^n = 0, \tag{E.17}$$

for all i and t. This implies that the net foreign asset position of a country is exactly equal to its investment in real bonds, i.e. $NFA_{i,t} = B_{i,t+1}$.

Market clearing for the non-tradable consumption good requires that in every country consumption is equal to production

$$C_{i,t}^N = Y_{i,t}^N. \tag{E.18}$$

Instead, market clearing for the tradable consumption good requires

$$C_{i,t}^T = Y_{i,t}^T + R_{t-1} B_{i,t} - B_{i,t+1}. \tag{E.19}$$

Finally, we generalize slightly, compared to the baseline economy, the world bond market clearing condition. In fact, we allow our model economy to run imbalances with respect to the rest of the world. More specifically, the bond market clearing condition is now

$$\int_0^1 B_{i,t+1} \, di = B^{rw}, \tag{E.20}$$

where B^{rw} is a constant, corresponding to bond supply by the rest of the world. This formulation allows us to capture, in our numerical simulations, the negative net foreign asset position toward the rest of the world characterizing our sample of advanced economy.

We are now ready to define a competitive equilibrium.

Definition 4 _Competitive equilibrium._ _A competitive equilibrium is a path of real alloca-_

tions $\{C_{i,t}, L_{i,t}, L^s_{i,t}, C^T_{i,t}, C^N_{i,t}, Y^N_{i,t}, B_{i,t+1}, B^n_{i,t+1}, \mu_{i,t}\}_{i,t}$, *policy rates* $\{R^n_{i,t}\}_{i,t}$ *and world interest rate* $\{R_t\}_t$, *satisfying* (E.2), (E.6), (E.8), (E.12), (E.13), (E.14), (E.16), (E.17), (E.18), (E.19) *and* (E.20) *given a path of endowments* $\{Y^T_{i,t}\}_{i,t}$, *a path for the borrowing limits* $\{\kappa_{i,t}\}_{i,t}$, *and initial conditions* $\{B_{i,0}\}_i$.

E.2 National planning problem and equilibrium with current account policies

To streamline the exposition of the planning problem, we impose, as in the numerical analysis, the parametric restriction $\sigma = 1/\xi$. This assumption simplifies the derivation of the planning problem. In particular, it implies that the labor supply equation (E.10) reduces to

$$L^s_{i,t} = \left(\frac{1-\omega}{\chi}\right)^{\frac{1}{\eta+\frac{1}{\xi}}} \equiv L^s, \tag{E.21}$$

where we have also used the fact that, when households work their desired amount of hours, $L^s_{i,t} = C^N_{i,t}$.

Define $z_{i,t} \equiv \{Y^T_{i,t}, \kappa_{i,t}\}$. The problem of the national planner in a generic country i can be represented as

$$V(B_{i,t}, z_{i,t}) = \max_{C^T_{i,t}, Y^N_{i,t}, B_{i,t+1}} \frac{\omega(C^T_{i,t})^{1-\frac{1}{\xi}} + (1-\omega)(Y^N_{i,t})^{1-\frac{1}{\xi}} - 1}{1 - \frac{1}{\xi}} - \frac{\chi(Y^N_{i,t})^{1+\eta}}{1+\eta} + \beta E_t\left[V(B_{i,t+1}, z_{i,t+1})\right] \tag{E.22}$$

subject to

$$C^T_{i,t} = Y^T_{i,t} - B_{i,t+1} + R_{t-1}B_{i,t} \tag{E.23}$$

$$B_{i,t+1} \geq -\kappa_{i,t} + \theta R_{t-1}B_{i,t} \tag{E.24}$$

$$Y^N_{i,t} \leq L^s \tag{E.25}$$

$$Y^N_{i,t} \leq C^T_{i,t}\left(\frac{R_t}{\bar{\pi}}\right)^\xi \Psi(B_{i,t+1}, z_{i,t+1}). \tag{E.26}$$

The resource constraints are captured by (21) and (23). (22) implies that the government is subject to the same borrowing constraint imposed by the markets on individual households.[57] Instead, constraint (24), which is obtained by combining the (E.12) and (E.16) equations, encapsulates the requirement that production of non-tradable goods is constrained by private sector's demand. The function $\Psi(B_{i,t+1}, z_{i,t+1})$ captures how the future planners' decisions affect constraint (24) in the present.[58] Since the current planner cannot make credible commitments about its future actions, these variables are not into its direct control. However, the current planner can still influence these

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[57]To write this constraint we have used the equilibrium condition $B^n_{i,t+1} = 0$.

[58]Formally, the function $\Psi(B_{i,t+1}.z_{i,t+1})$ is defined as

$$\Psi(B_{i,t+1}, z_{i,t+1}) \equiv \left(\frac{E_t\left[\frac{\omega}{\mathcal{C}^T(B_{i,t+1},z_{i,t+1})^{\frac{1}{\xi}}} - \theta\mu(B_{i,t+1}, z_{i,t+1})\right]}{E_t\left[\left(\frac{\mathcal{C}^T(B_{i,t+1},z_{i,t+1})}{\mathcal{Y}^N(B_{i,t+1},z_{i,t+1})}\right)^{\frac{1}{\xi}}\left(\frac{\omega}{\mathcal{C}^T(B_{i,t+1},z_{i,t+1})^{\frac{1}{\xi}}} - \theta\mu(B_{i,t+1}, z_{i,t+1})\right)\right]}\right)^\xi,$$

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quantities through its choice of net foreign assets. In what follows, we focus on equilibria in which $\Psi(B_{i,t}, z_{i,t})$ is differentiable. This is the case in the numerical simulations considered in the paper.

To solve this problem, we start by guessing that constraint ($E.25$) does not bind. The planner's first order conditions can then be written as

$$\bar{\lambda}_{i,t} = \frac{\omega}{(C_{i,t}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} \tag{E.27}$$

$$\bar{v}_{i,t} = \frac{1-\omega}{(Y_{i,t}^N)^{\frac{1}{\xi}}} - \chi(Y_{i,t}^N)^\eta \tag{E.28}$$

$$\bar{\lambda}_{i,t} = \beta R_t E_t \left[\bar{\lambda}_{i,t+1} - \theta \bar{\mu}_{i,t+1} \right] + \bar{\mu}_{i,t} + \bar{v}_{i,t} Y_{i,t}^N \frac{\Psi_B(B_{i,t+1}, z_{i,t+1})}{\Psi(B_{i,t+1}, z_{i,t+1})} \tag{E.29}$$

$$B_{i,t+1} \geq -\kappa_{i,t} + \theta R_{t-1} B_{i,t} \quad \text{with equality if} \quad \bar{\mu}_{i,t} > 0 \tag{E.30}$$

$$Y_{i,t}^N \leq C_{i,t}^T \left(\frac{R_t}{\bar{\pi}} \right)^\xi \Psi(B_{i,t+1}, z_{i,t+1}) \quad \text{with equality if} \quad \bar{v}_{i,t} > 0, \tag{E.31}$$

where $\bar{\lambda}_{i,t}, \bar{\mu}_{i,t}, \bar{v}_{i,t}$ denote respectively the nonnegative Lagrange multipliers on constraints ($E.23$), ($E.24$) and ($E.26$), while $\Psi_B(B_{i,t+1}, z_{i,t+1})$ is the partial derivative of $\Psi(B_{i,t+1}, z_{i,t+1})$ with respect to $B_{i,t+1}$.

Note that equation ($E.28$) implies that, as we guessed, constraint ($E.25$) does not bind. Intuitively, the labor supply decision of the planner coincides with the households' one.

It is useful to combine ($E.27$) and ($E.29$) to obtain

$$\frac{\omega}{(C_{i,t}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t} \frac{Y_{i,t}^N}{C_{i,t}^T} = \beta R_t E_t \left[\frac{\omega}{(C_{i,t+1}^T)^{-\frac{1}{\xi}}} + \bar{v}_{i,t+1} \frac{Y_{i,t+1}^N}{C_{i,t+1}^T} - \theta \bar{\mu}_{i,t+1} \right]$$
$$+ \bar{\mu}_{i,t} + \bar{v}_{i,t} Y_{i,t}^N \frac{\Psi_B(B_{i,t+1}, z_{i,t+1})}{\Psi(B_{i,t+1}, z_{i,t+1})} \tag{E.32}$$

This is the planner's Euler equation. We are now ready to define an equilibrium with current account policy.

Definition 5 *Equilibrium with current account policy. An equilibrium with current account policy is a path of real allocations $\{C_{i,t}^T, Y_{i,t}^N, B_{i,t+1}, \bar{\mu}_{i,t}, \bar{v}_{i,t}\}_{i,t}$ and world interest rate $\{R_t\}_t$, satisfying ($E.20$), ($E.23$), ($E.28$), ($E.30$), ($E.31$) and ($E.32$) given a path of endowments $\{Y_{i,t}^T\}_{i,t}$, a path for the borrowing limits $\{\kappa_{i,t}\}_{i,t}$, and initial conditions $\{B_{i,0}\}_i$. Moreover, the function $\Psi(B_{i,t+1}, Y_{i,t+1}^T)$ has to be consistent with the national planners' decision rules.*

where $\mathcal{C}^T(B_{i,t+1}, Y_{i,t+1}^T)$ and $\mathcal{Y}^N(B_{i,t+1}, Y_{i,t+1}^T)$ determine respectively consumption of tradable goods and production of non-tradable goods in period $t+1$ as a function of the state variables at the beginning of next period. In turn, $\mu(B_{i,t+1}, z_{i,t+1})$, households' Lagrange multiplier on the borrowing constraint, is defined as

$$\mu(B_{i,t+1}, z_{i,t+1}) = \frac{\omega}{\mathcal{C}^T(B_{i,t+1}, z_{i,t+1})^{\frac{1}{\xi}}} - \beta R_{t+1} E_t \left[\frac{\omega}{\mathcal{C}^T(B_{i,t+2}, z_{i,t+2})^{\frac{1}{\xi}}} - \theta \mu(B_{i,t+2}, z_{i,t+2}) \right].$$

F   Numerical solution method

To solve the model numerically we follow the method proposed by Guerrieri and Lorenzoni (2017).

We start by discussing the computations needed to solve for the steady state. Computing the steady state of the model involves finding the interest rate that clears the bond market at the world level. The first step consists in deriving the optimal policy functions $C^T(B,z)$ and $C^N(B,z)$, where $z = \{Y^T, \kappa\}$ for a given interest rate R. To compute the optimal policy functions we discretize the endogenous state variable B using a grid with 500 points, and then iterate on the Euler equation and on the intratemporal optimality conditions using the endogenous gridpoints method of Carroll (2006). The decision rule $C^T(B,z)$, coupled with the country-level market clearing condition for tradable goods, fully determines the transition for the country's bond holdings. Using the optimal policies, it is then possible to derive the inverse of the bond accumulation policy $g(B,z)$. This is used to update the conditional bond distribution $M(B,z)$ according to the formula $M_\tau(B,z) = \sum_z M_{\tau-1}(g(B,\tilde{z}),\tilde{z}) P(z|\tilde{z})$, where τ is the τ-th iteration and $P(z|\tilde{z})$ is the probability that $z_{t+1} = z$ if $z_t = \tilde{z}$. Once the bond distribution has converged to the stationary distribution, we check whether the market for bonds clears. If not, we update the guess for the interest rate.

To compute the transitional dynamics, we first derive the initial and final steady states. We then choose a T large enough so that the economy has approximately converged to the final steady state at $t = T$ (we use $T = 100$, increasing T does not affect the results reported). The next step consists in guessing a path for the interest rate. We then set the policy functions for consumption in period T equal to the ones in the final steady state and iterate backward on the Euler equation and on the intratemporal optimality conditions to find the sequence of optimal policies $\{C_t^T(B,z), C_t^N(B,z)\}$. Next, we use the optimal policies to compute the sequence of bond distributions $M_t(B,z)$ going forward from $t = 0$ to $t = T$, starting with the distribution in the initial steady state. Finally, we compute the world demand for bonds in every period and update the path for the interest rate until the market clears in every period.

G   Sensitivity analysis

In this appendix we discuss how the results are affected by changes in some key model parameters.

We start by considering changes in the Frisch elasticity of labor supply $1/\eta$. This is an important parameter, because it determines the impact on welfare of deviations of employment from its natural value. More precisely, the lower the Frisch elasticity the higher the welfare losses associated with involuntary unemployment. In our benchmark parametrization we considered a Frisch elasticity of 0.45, in line with the value used by the New Keynesian literature. However, in our setting this assumption is likely to underestimate the welfare costs of unemployment. This is due to the fact that in the benchmark New Keynesian model there is no involuntary unemployment. Instead, in our world characterized by wage rigidities all the fluctuation in employment are involuntary. It is then interesting to see how the results change when the welfare costs associated with fluctuations in unemployment increase.

Table 3. Sensitivity analysis

	Output losses	Welfare losses	Welfare losses (NT)
Benchmark	1.22	0.09	0.30
Lower Frisch elasticity ($1/\eta = 0.35$)	1.76	0.23	0.52
Higher Frisch elasticity ($1/\eta = 0.55$)	0.54	-0.02	0.09
Lower inflation ($\bar{\pi} = 1.000$)	2.01	0.25	0.52
Higher inflation ($\bar{\pi} = 1.015$)	0.40	-0.03	0.06
Elastic B^{rw} (low, $\zeta = 1$)	0.74	0.00	0.16
Elastic B^{rw} (high, $\zeta = 10$)	0.25	-0.05	0.02

Notes: All the numbers are in percent. For each variable the table shows its average cross-sectional value.

The second row of Table 3 shows that lowering the Frisch elasticity to 0.35 substantially increases both the output and welfare losses caused by current account policies. This result is due to the fact that higher welfare costs from unemployment induce governments to intervene more aggressively on the current account. Hence, the implementation of current account policies leads to a larger drop in the world interest rate, which exacerbates the inefficiencies due to the zero lower bound compared to our benchmark parametrization. As a result, lowering the Frisch elasticity to 0.35 more than doubles the welfare losses triggered by current account policies with respect to the benchmark parametrization. The third row of table 3 shows that, as it is natural, the opposite occurs for a higher value of the Frisch elasticity equal to 0.55.

In our second experiment we consider changes in inflation $\bar{\pi}$. As it is well known higher inflation expectations, in our model captured by a higher $\bar{\pi}$, reduce the constraint on monetary policy imposed by the zero lower bound on the policy rate. In our benchmark parametrization we have set $\bar{\pi} = 1.0125$. This is lower that the 2% inflation target characterizing countries such as the US or Euro area, but higher than the average inflation experienced by countries undergoing long-lasting liquidity traps such as Japan.

It turns out that in our model even relatively small variations in inflation expectations can have a substantial impact on the output and welfare losses triggered by current account interventions. For instance, lowering $\bar{\pi}$ to 1 roughly doubles the output and welfare losses associated with current account policies. Instead, increasing $\bar{\pi}$ to 1.015 substantially mitigates the drop in global output triggered by the implementation of current account policies. Moreover, in this case the average impact on welfare of current account policies is slightly positive. However, current account interventions still exacerbate the inefficiencies due to the zero lower bound. In fact, once the focus is restricted to the non-tradable sector, current account policies have a negative impact on welfare is negative. These results suggests that inflation expectations play a key role in shaping the impact of current account policies on the global economy.

To conclude, we relax the assumption of an inelastic bond supply from the rest of the world. In particular, we assume that the supply of bonds from the rest of the world is given by

$$B_t^{rw} = B^{rw} \left(\frac{R_t}{R^{lf}} \right)^{\zeta},$$

so that the supply of bonds by the rest of the world is increasing in the world interest rate. Notice that this specification implies that in the laissez-faire steady state the bond supply from rest-of-the-world countries takes the same value as in our benchmark calibration. The parameter ζ captures the elasticity of B_t^{rw} with respect to R_t, and hence by how much the world interest rate falls as a consequence of the adoption of current account policies. Unfortunately, we could find reliable estimates for this elasticity.[59] Hence, we report the results for two benchmark value, $\zeta = 1$ (low elasticity) and $\zeta = 10$ (high elasticity).

The key difference with respect to the benchmark economy with inelastic B^{rw}, is that now the parameter ζ is a key determinant of the response of R to the implementation of current account policies. More precisely, the higher ζ the less R will drop after an increase in the supply of savings by our model economies. It is then natural to think that the negative impact that current account policies will have on world output will be milder the higher ζ. This is precisely the result shown by the two last rows of Table 3. However, current account policy produce a substantial drop in world output even when ζ takes the relatively high value of 10. A similar result applies to the welfare losses driven by the fact that current account policies exacerbate the inefficiencies due to the zero lower bound constraint. In fact, once the focus is restricted to the non-tradable sector, current account policies have a negative impact on welfare even for $\zeta = 10$. Summing up, while assuming an elastic supply of bonds from the rest of the world changes the quantitative predictions of the model, the results that current account policies depress global output and exacerbate the inefficiencies due to the zero lower bound hold for relatively high elasticities.

H   Data appendix

This appendix provides details on the construction of the series used in the calibration and to construct Figure 1.

H.1   Data used in the calibration

The countries in the sample are Australia, Austria, Canada, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Netherlands, Portugal, Spain, Sweden, Switzerland, United Kingdom and United States.

1. *World interest rate.* The series for the world interest rate is constructed by Rachel and Smith (2015) following the methodology proposed by King and Low (2014).[60]

2. *Net foreign assets.* The data for the net foreign asset position and GDP come from External Wealth of Nations' dataset by Lane and Milesi-Ferretti (2007).

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[59]As we alluded to in the main text, the key challenge is that a significant fraction of lending from emerging to advanced countries is in the form of reserve accumulation by emerging countries' governments. These flows might be driven by different considerations than the standard trade-off between risk and return. Because of this, it is hard to pin down quantitatively how these flows react to changes in the world rate.

[60]We thank Lukasz Rachel for providing us with the data.

3. *Core inflation rate.* Core inflation is computed as the percentage change with respect to the previous year of the CPI for all items excluding food and energy. The series are yearly and provided by the OECD.

4. *Tradable endowment process.* Tradable output is defined as the aggregate of value added in agriculture, hunting, forestry, fishing, mining, manufacturing and utilities. To extract the cyclical component from the actual series we used the following procedure. For each country we divided tradable output by total population and took logs. Since our model abstracts from aggregate shocks, for every year we subtracted from the country-level series the logarithm of the average cross-sectional tradable output per capita. For every country we then obtained the cyclical component of the resulting series by removing a country-specific log-linear trend. The first order autocorrelation and the standard deviation of the final series are respectively 0.87 and 0.056. We use yearly data for the period 1970-2015, coming from the United Nations' National account main aggregate database.

5. *Identifying financial crises.* We identify a financial crisis in the data as an episode in which the cyclical component of the trade balance is one standard deviation above its average and the cyclical component of tradable output, as defined above, is one standard deviation below its average. We define the start of a financial crisis as the first year in which the cyclical component of the trade balance is half standard deviation above its mean, while a financial crisis ends when the cyclical component of the trade balance falls below one standard deviation above its mean.

   To compute the cyclical component of the trade balance we used the following procedure. We collected yearly series for the trade balance for the period 1970-2015 from the OECD. The data are in 2010 constant US dollars. For each country, we then divided by total population. Since our model abstracts from aggregate shocks, for every year we subtracted the cross-sectional average from the series. Finally, we obtained the cyclical component from the resulting series by subtracting a country-specific linear trend.

H.2 Data used to construct Figure 1

1. *Policy rates.* Monthly series. US: Effective Federal Funds Rate from the Fed Board of Governors of the Federal Reserve System. Euro area and Japan: Central bank discount rate from the IMF International Financial Statistics database. UK: Bank of England policy rate.

2. *GDP per capita.* Constant prices, series from the World Bank.

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